# THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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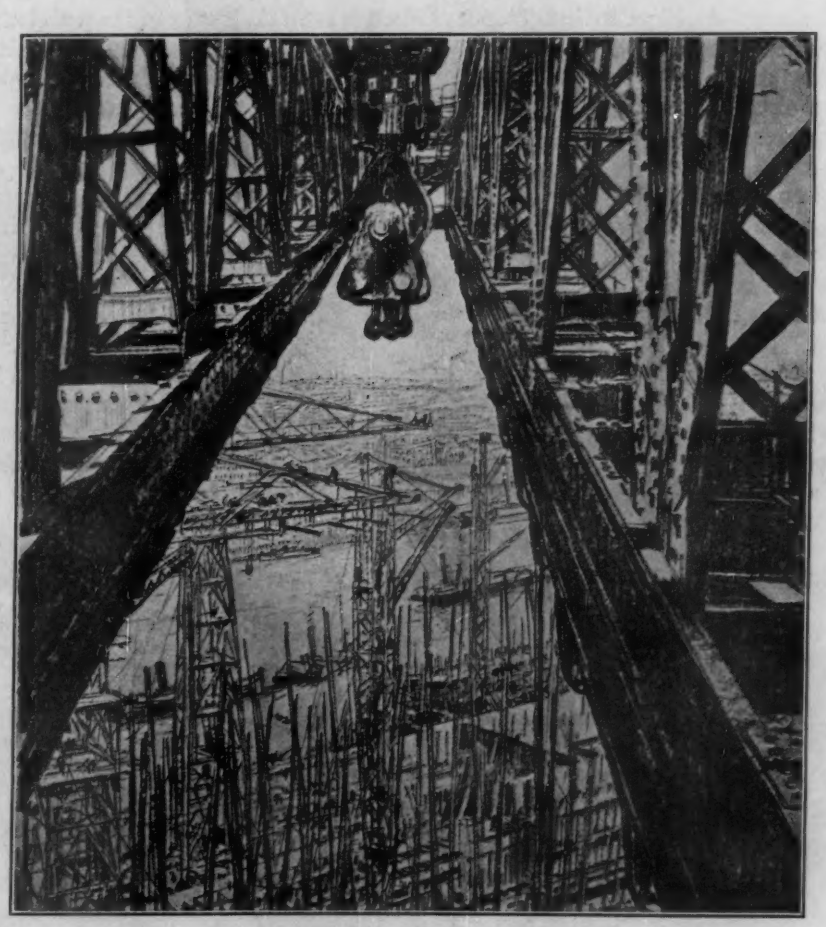

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# *Lead* has a lot to say about your *gasoline*

PROBABLY you never realized what a necessary business the petroleum industry is until, one dark night, the old bus wheezed to a stop and you had to walk the traditional weary miles to the nearest gas station.

Right there, as the pump gurgled out the precious liquid, you should have raised your hat in silent tribute to—Lead. But you didn't know what a good bit of service lead was doing you.

Lead has found itself several essential jobs in the petroleum industry.

In the first place, oil wells often give out more water than oil. The most economical way to shut off the flow of water is to drop a plug of EAGLE Lead Wool into the bottom of the well. Pressure pounds the lead wool into every water crevice and stops the flow at once.

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# Saving over $90,000 per year for the New York Steam Corp.

THE load at the New York Steam Corporation's plant recently reached a point at which the company's engineers had to either force the existing boilers far beyond their efficient operating range or else install additional equipment.

New boilers would have required a heavy investment in expensive land and a new building. It was therefore decided to install economizers. A study of the existing conditions immediately revealed one of the outstanding advantages of Foster design, for no other economizers could have been installed in the space available in the plant without extensive building alterations.

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Here, as in many other installations all over the country, Foster Economizers are proving a mighty profitable investment.

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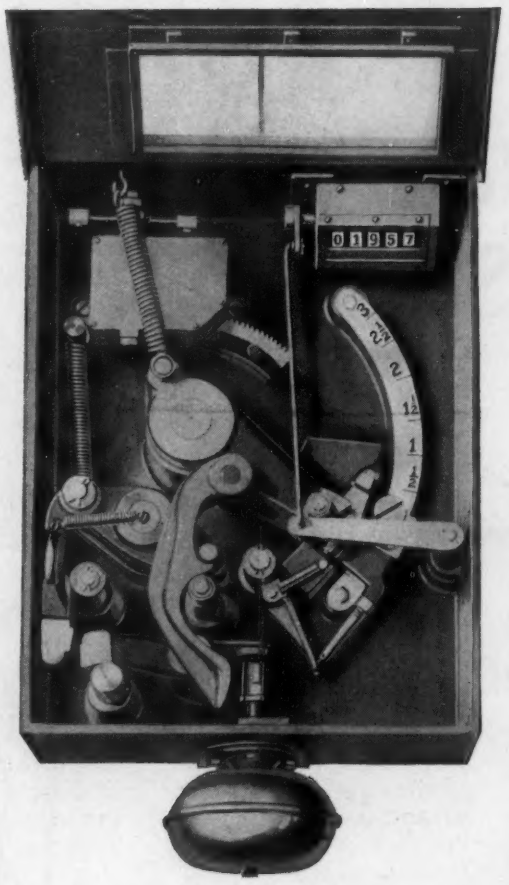
*This illustration of the Koehring escapement type batch meter shows the method by which the discharge chute is automatically locked as soon as the charge enters the drum. The discharge chute cannot be moved until the regulated mixing time has elapsed, when it automatically releases the discharge lever and signals the fact with a bell. The meter also registers each batch that enters the drum.*

Patent Nos.
1,321,460; 1,282,558, 1,338,761.




THE Koehring Company long ago foresaw the *value* of standardizing concrete,—foresaw and provided for it before the tremendous volume used in constructing roads and permanent structures made standardized concrete a vital *necessity*.

One of the most important means of insuring a uniform strength and quality of concrete is the Koehring Batch Meter,—a positive means for timing each batch and measuring the thoroughness of mix. This device, upon being set for the specified mixing period, automatically locks the discharge chute as soon as the drum receives the materials; the discharge chute cannot then be operated until the full specified mixing time has elapsed.

Every state highway department requires, in its specifications for concrete highway construction, the use of batch meters. This Koehring development is an integral unit on practically every paving mixer today,—a Koehring contribution to the industry.

The Koehring mixer, with the Koehring batch meter, Koehring five action re-mixing principle, and the Koehring automatic water measuring tank, provides the most positive mechanical means yet developed for producing standardized concrete of unvarying uniformity.

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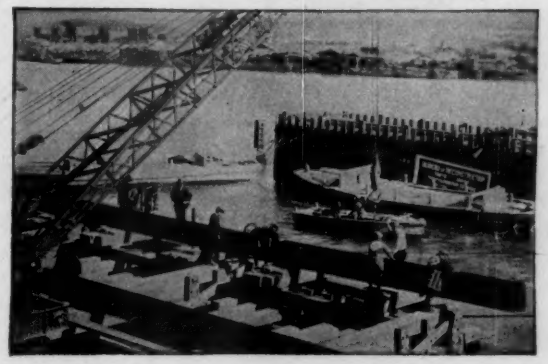
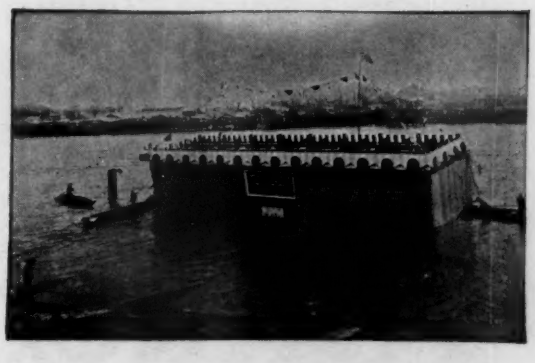
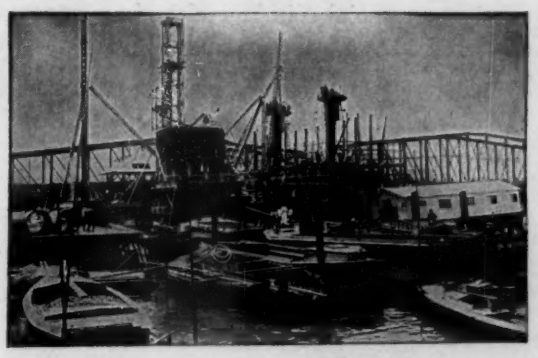
# "Sandhogs" Are Working In Japan







Pneumatic caissons and the men who work under air pressure within them—called "Sandhogs"—have been introduced into Japan by The Foundation Company.

As a result of the great earthquakes in 1923, and to avoid future destruction should they recur, unusual forms of construction are being used in Japan.

The Capital, Tokyo, like Venice, has a maze of waterways and many bridges span them. In the building of new bridges over the Sumida River, which divides the city, construction under air pressure was necessary to reach stable foundations.

Importing modern pneumatic equipment from America, the Japanese, under the supervision of Engineers of The Foundation Company, have built the new bridge piers.

The laying of a cutting edge of a caisson; the launching of one; and the installation of pneumatic equipment are shown in the views.

Foundations are but one of many types of structures built by this organization.

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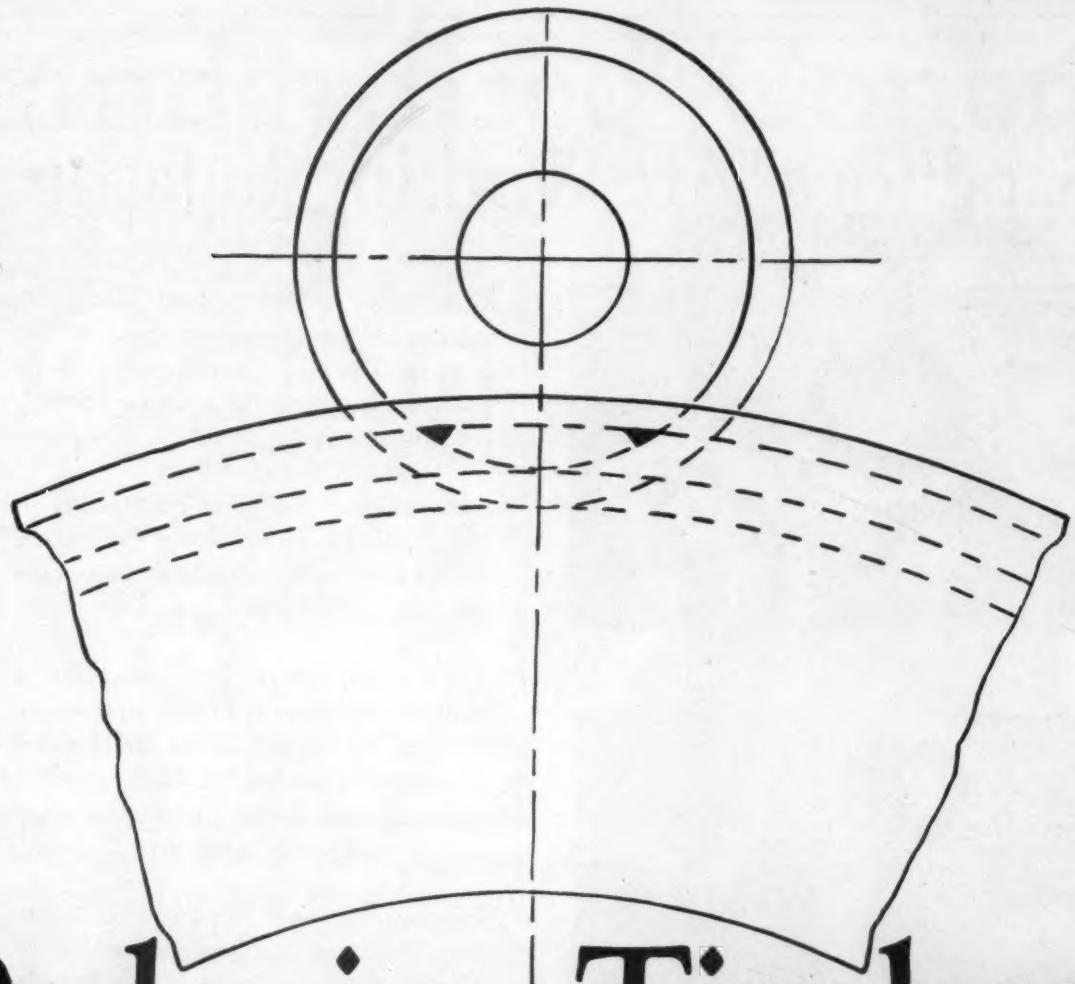

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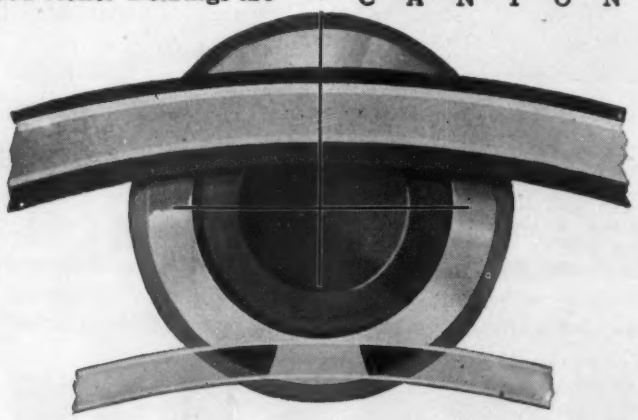

*The Timken Engineering Journal consists of 110 pages of engineering material, including bearing tables, recommendations for bearing applications and other authentic, informative material. Copies are available for faculty members requesting them.*

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# THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VII OCTOBER, 1926 NUMBER 4


# X-Rays

*An outline of the characteristics of X-radiation which make possible its application in a practical way to scientific and industrial problems*


*By* JOHN T. NORTON, '18
Assistant Professor of Physics, Massachusetts Institute of Technology


THE important part which research plays in scientific and industrial development can hardly be overestimated. From one point of view at least, research consists of obtaining all possible information about a particular subject and arranging and tabulating this information in such a fashion that it will be of use. To be really valuable, a piece of research shoud be complete and to this end, the research worker should be familiar with all of the methods of obtaining information about his particular subject and be able to apply these methods in an intelligent manner. It is also important that the limitations of the methods be realized so that a loss of time and expense may be avoided. This paper is concerned with a type of radiation commonly referred to as "X-rays" which has recently found wide use as a research tool in the study of many technical and industrial problems.

The general subject of the application of X-rays has no very satisfactory title. The term radiology has been used to quite an extent and for lack of a better, will be used in this instance. Radiology seems to have made for itself a definite place among the other tools which the research workers employ. Although X-rays have only been known for about thirty years and their nature understood for something like half of that time, radiology has been developed to a remarkable degree and this development has been assisted by some of the foremost scientific men of modern times. The subject is of such fascinating interest that it is not surprising that so many people have become interested in it.

X-radiation possesses some properties which are peculiar to itself and it is these properties which make possible its use as a research tool. It will not be out of place, perhaps, to say a few words about the nature of X-radiation and some of its properties.

In many ways, X-radiation is similar to ordinary light. The physicist is accustomed to think of light as a radiation by means of which energy is transferred from one point to another in space. This transfer takes place with a definite measurable velocity and there is associated with the radiation a definite periodicity or frequency. The radiation is unquestionably of an electromagnetic sort but the exact nature of the process by which this transfer of energy takes place is the subject of much spirited controversy. X-radiation differs from ordinary light only in the matter of frequency, the frequency which is associated with light being very much lower than of the X-rays. This difference is analogous to the difference between two musical notes several octaves apart. The frequency of the X-radiation is so high that the mechanism of the eye cannot respond and hence we cannot see it as we can visible light, but there are other ways of detecting it. This is again analogous to a sound which is of too high a pitch for the ear to detect.

*This article is the first of several by Professor Norton which will cover this new and rapidly growing scientific development. This first article is an introduction to the X-rays themselves, explaining their nature and properties. The next article, to appear in the November issue will take up one of the uses of X-rays; their employment for the purpose of identifying materials.*

It is interesting to observe the way in which the various kinds of electromagnetic radiation are related. It is found that if they are grouped according to their wavelength that they form an almost continuous series from the longest electric waves to the shortest gamma rays and that the various regions merge into one another in a continuous fashion. This is known as the electromagnetic spectrum. One of the striking features is that of the some sixty octaves of radiation, the eye is sensitive to only about one. The regions between the electric and infrared and between the ultra-violet and X-rays have been very difficult of investigation because the ordinary methods have been found not to apply directly but by modification and improvement, these gaps have been gradually filled until at present the whole spectrum is complete.

The properties of this type of radiation are rather interesting. The radiation travels with the velocity of light which is about 186000 miles a second. Just as there are different colors of visible light and different wavelengths of the electric waves used for radio transmission, so are there different frequencies or wavelengths of X-rays. As they are commonly employed, the wavelengths extend over a range from .01 to 1.0 Angstrom units, one of these units being equal to a hundred millionth of a centimeter. This is an

*(Continued on page 190)*

# Engineering and Human Progress

## *The advances of the past fifty years bring their responsibilities as well as their advantages*

*By* A. A. POTTER
Dean of the School of Engineering,
Purdue University

THE past fifty years have been the most notable on record as far as engineering achievements are concerned. During these years, the engineering profession rose in dignity and importance as people realized that engineering is a profession of creation and construction, of stimulation of human effort and accomplishment.

Engineering has demonstrated that the most efficient way to utilize man's capacity for work is to allow him by his skill and knowledge to direct and control machinery by which work is performed. It has been estimated that in this country about seven mechanical horse power, the equivalent of more than 100 human slaves, are available per capita of our population to do for us the work of drudgery. This enormous strength of ours in the form of mechanical power has stimulated industrial development and has utterly changed the conditions of human life.

Engineering has contributed greatly during the past fifty years to the development of electricity so that we are able to see into the night by electric light, to communicate with others by telephone, telegraph and radio, to see the world in moving pictures, to explore the human body by X-rays, and to travel great distances by electric traction.

The first electric central station in this country was started in September 1882, or about 43 years ago. At present the electric generating stations represent an investment of over six and one-half billion dollars, are serving over seventeen million customers and have an annual revenue of over 1,500 million dollars.

The telephone which was unknown fifty years ago is now used in this country for sending over sixty million messages daily. About sixteen million telephones are in use, or about one telephone for every seven inhabitants of the United States of America.

Radio was unknown even twenty-five years ago, but at present over 400 million dollars of radio equipment is being sold the U. S. A. per year. The amount spent for radio per year is about one-third that spent for furniture or about one-fourth that spent for boots and shoes. Radio business has increased more than ten fold since 1921.

Improvements in transportation are making our raw materials and our manufactured products more accessible, are shortening open spaces, are improving life in many inaccessible places, are bringing communities within social and commercial range of each other, and are greatly responsible for the stability of our government.

*This article was composed from the substance of a very interesting talk given to the class of '26 last spring under the auspices of the Mechanical Engineering Society. Because it summarizes the engineering development of the last half century, points towards the future, and explains the mission of the engineer, we feel that Mr. Potter's article is especially suited for the fall number of* **The Tech Engineering News.**

Fifty years ago there were no electric railways. At the present time, the steam railroad mileage of 260,000 miles is supplemented by about 44,000 miles of electric railway mileage. These electric railways have a record of about two billion passenger miles per year in addition to the 47 billion passenger miles per year on record for the steam railroads.

The automobile was unknown fifty years ago. At the present time, about 18 million automobiles enable every other family in the U. S. A. to travel in any direction at any time and at any speed. These American automobiles cover a distance which is equivalent to the circling of the globe more than twenty thousand times daily, consume annually over six billion gallons of gasoline and 600 million pounds of rubber, and necessitate an annual expenditure of nearly 1 1-2 billion dollars for the construction and maintenance of passable roads in every part of the country.

Fifty years ago, our manufacturing establishments produced the coarser materials which were turned into useful articles in European industries. At present the United States of America is the greatest manufacturing nation in the world. Our 300,000 manufacturing establishments represent a capital investment of about 45 billion dollars and their products are valued at about sixty billion dollars. In these industries about nine million people are employed who receive annually about 10 1-2 billion dollars in wages. Each American factory worker has 3 1-2 mechanical horse power, equivalent to about 70 human slaves, to supplement his labor. With this amount behind him, he produces more goods, commands higher wages and lives better than any workers in the world. The enlarged production per worker which has resulted in increasing the wealth and physical well being of our people may be considered among the chief contributions of engineering.

Electrical energy to a constantly increasing extent is being used for turning the wheels of American industry. The adoption of the electric drive in industry is going on with great rapidity. Motors with widely varied characteristics are being built in sizes and speeds to suit all types of industry. The manufacturer can purchase a fractional horse power motor as small as one three-hundredth of a horse power or as large as 20,000 horse power. Electric motors are available in speeds as low as 100 revolutions per minute for wood working machines. About 34 billion kilowatt-hours of electrical energy per year is used for power in the industrial plants of the United States of America. Of this, about two-thirds is being supplied by public utility electric central stations and about one-third is generated in isolated power plants in connection with industrial plants.

The period in which we are living has been called the "Age of Mechanical Power". The power consumption per capita is a measure of the progress of a nation. Mechanical power is usually developed by harnessing water falls or by utilizing the heat energy of some fuel such as coal, oil or gas.

As water must run to waste whether used or not, there is a popular impression that water power costs nothing and that all electricity should be developed by utilizing water power. Actually, less than one-third of the electricity is developed in the U. S. A. in water power plants, over two-thirds in steam power plants and about 3% in gas and oil engine plants. The water power plant involves geographic restriction and is practical only if a plentiful supply of water can be had at a fairly high head.

For the generation of power, especially in large amounts the steam power plant has been found most satisfactory, on account of the lower first cost per unit of power developed and the greater reliability. The steam turbine is at present the most important type of steam prime mover in connection with electric power generation and its use is constantly increasing. The steam turbines develop at present more power in electric central stations than all reciprocating steam engines, gas and oil engines and water turbines combined. The popularity of the steam turbine for electric power generation is based on the following facts: The steam turbine operates at practically uniform speed, occupies less space per unit capacity than other motors, can be built in very large sizes at low cost and is very economical particularly in large capacities. Reciprocating engines of capacities greater than 5,000 horse power are very rare. Steam turbines are now in operation which have capacities of 50,000 to 80,000 kilowatt, corresponding to between 70,000 and over 100,000 horse power. Steam turbines of 10,000 kilowatt to 30,000 kilowatt are very common. (A kilowatt is equal to about 1 1-3 horse power.)

As the electric public utilities of this country lead the world in economy of power production as well as in magnitude of production the trends in the design and operation of their power plants are followed by the most progressive industrial plants. these may be summarized as follows:

The output of the electric utilities in kilowatt-hours has more than doubled during the past ten years at an increase of about 5 per cent in the fuel used. The average coal consumption by these utilities has been decreased from 3.2 lb. per kilowatt-hour in 1919 to 2.2 lb. per kilowatt-hour in 1924. The best and largest of these electric central stations are at present generating a kilowatt-hour on less than two pounds of coal.

These gains in economy have been brought about mainly by improvements in the boiler room. Modern methods have not only increased the efficiency of the boiler but also its steaming capacity. There is a general trend toward higher steam pressures and temperatures in both the electric central stations and industrial power plants. Steam pressures carried in the large power plants have more than doubled in the past few years. Extra high pressure steam is particularly advantageous in the industrial plant using steam for process work as well as for power generation. 600 pound and 750° F. are considered practical pressures and temperatures for large power plants. In a few cases even higher pressures are contemplated. The Boston Edison has installed at Weymouth, Massachusetts a boiler to generate steam at 1,200 lb. pressure. In Rugby, England tests have been carried on with a Benson boiler the object being to demonstrate that steam can be generated at a pressure as high as 3,200 lb.

The mercury turbine gives promise of materially increasing the efficiency of power plants by extending the temperature range.

Steam making surfaces in boilers are being arranged to better advantage. Furnace volumes are being increased to make operation at higher ratings possible. Very few boilers are now operated at ratings below 200 per cent and in some cases, boilers have been forced to 700 per cent rating.

Powdered coal is being introduced in many of the newer large power plants. It is particularly advantageous for localities where the quality of the coal supplied is not uniform. High furnaces and the use of powdered fuel have brought about improvements in refractories for boiler settings and the adoption of water-walled furnaces.

In Continental Europe steam accumulators are being used in electric central stations as well as in industrial plants to take care of fluctuations in steam demands. In Sweden improved combustion conditions due to the use of accumulators have resulted in considerable fuel economy. Chemical industries, pulp and paper mills, steel plants and other industries will do well to watch the development of the accumulator and to consider its use in this country to improve fuel economy.

Improvements in the steam cycle, increased boiler efficiency, higher steam pressures and temperatures, greater attention to heat balance, air preheating and regenerating cycles all tend to reduce fuel consumption to about one pound per kilowatt-hour.

Science and engineering have contributed greatly to human welfare and have made prodigious changes in social conditions, standards of living and industrial development.

This improvement in the standards of our living has gone on simultaneously with a more general appreciation of scientific and engineering education. One hundred years ago, or in 1824, the first engineering college in English speaking countries was started in the U. S. A. at Troy, New York. This is the Rensellaer Polytechnic Institute, the father of American Engineering Colleges. At the present time, the United States of America has about 137 engineering colleges which are training about 55,000 students and are graduating annually about 9,000 technically trained engineers.

Engineering is assuming a constantly greater place in the lives of civilized nations and the engineering colleges have a great responsibility to train men who will not only be capable as engineers, but who will be able to take an active and leading part in coping with the social readjustments which are becoming at once increasingly necessary and difficult. The constantly increasing use of power, the tremendous industrial developments and the miraculous achievements of science and engineering in annihilating time and distance increase the responsibility of our engineering colleges to develop men who have a broad outlook, an appreciation of the sanctity of humanity and interest in the common good. The engineer is in a position to help greatly in insuring the permanency of our civilization if he will always direct for the benefit of humanity the new forces which science and engineering are constantly creating. The product of our engineering colleges must be engineers of broad calibre who have the ability to solve the technical problems of their specialty and who will utilize their scientific and engineering knowledge as tools in the building of a rational world.

The engineering colleges are preparing men for the practice of the engineering profession. These men are trained to have a broad acquaintance with present conditions, an appreciation of the importance of right living, a scientific spirit, capacity for unselfish service to society and an interest in the advancement of the common good. Engineering educators have always been in accord with the statement of Theodore Roosevelt that "to educate a man in mind and not in morals is to educate a menace to society." The engineering student is being constantly impressed with the fact that the stability of society depends upon the character of the people; that capacity to do carries with it a responsibility to society; also that knowledge and talent are of no value to an engineer unless he is trusted and respected by his fellow men. An effort has been made to teach the engineering students only fundamentals; it is to train men who

*(Continued on page 196)*

# The National Air Races

## *A review of the new developments exhibited this year at the Model Farm Field, Philadelphia*

*By* Mac Short, '26
Department of Aeronautical Engineering,
Massachusetts Institute of Technology

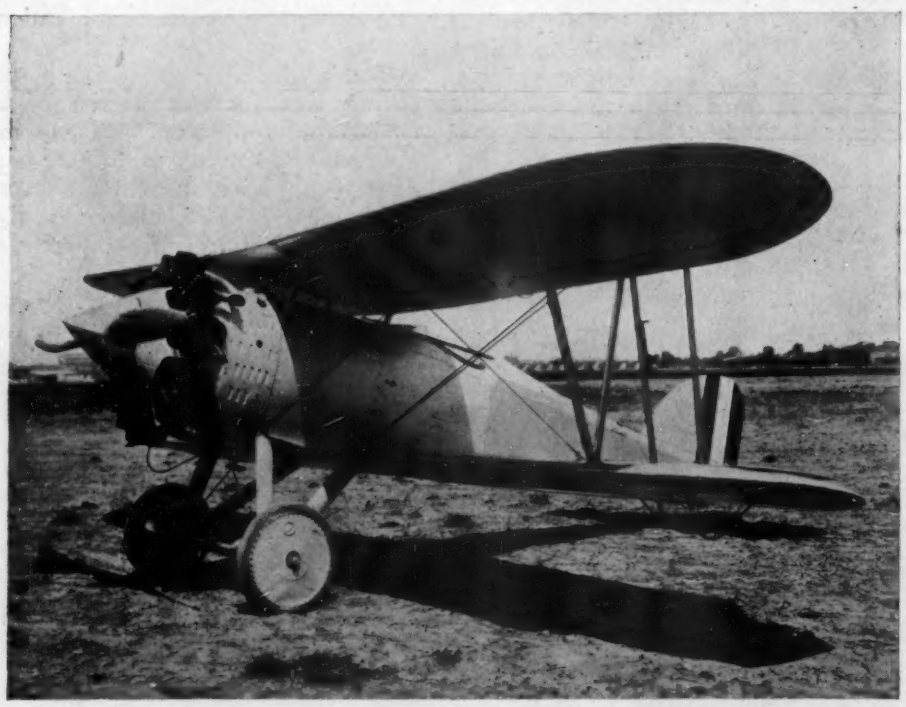
THE National Air Races are fast becoming a national institution. Even before the 1926 races were completed, plans were underway for the selection of the city in which the next meet will be held. At the conclusion of the 1925 air races, held at Mitchel Field on Long Island, Philadelphia, because of the Sesqui-Centennial Exposition, was selected as the logical city for this year. The customary date for these national aerial contests has been, in the past, during the first week of October, however, this year it was moved up a month with the hope that the weather would be more suitable for the fliers and spectators alike. The air races were held at the Model Farms Field, a field selected and conditioned especially for this event by the city of Philadelphia. The "On-To-The-Sesqui" race terminated at midnight of September the 3rd, with the field events extending from the 4th to the 11th. Due to a series of severe rain storms, which caused the newly made field to become very soft, the contests were not started until the 8th.

### *The "On-To-The-Sesqui" Race*

At each national air race there has been an "On-To" event and although there are few eye witnesses, principally the flying field personnel and a few visitors who assist the men as they stop to refuel at the various aviation fields along their route, this event bespeaks more of the qualities of the airplane, which are of more concern to the flying public, than do the majority of the races held over a closed course during the meet. A scoring system based on the piston displacement of the engine, the pay load and the elapsed time between the starting point and the Model Farms Field determined the winner of the race. The minimum distance from which a pilot could fly was 200 miles while the maximum was left to his own discretion. In order that points might be secured from speed, a minimum of 50 miles per hour for the elapsed time was set from which to begin scoring. Points awarded for load were in proportion to the pay load carried, and here also a minimum was set.

Entered in this race were commercial pilots from all points of the United States and it is interesting to note that the first three prizes were awarded to men who flew from exceedingly long distances. The winner was F. D. Hoyt of Santa Monica, California flying a 90 H.P. Travel Air airplane. In order to gain a few more points for distance he began his log of the flight from Eureka, California, which is substantially the furtherest distant city on the California coast from Philadelphia. He flew 2558 miles in a total elapsed time of 83 1-2 hours of which 31 hours represented actual flying time accrued while doing daylight flying only.

In connection with the flight from California an interesting comparison developed between traveling by airplane and by automobile. Over practically the same period and the same route which Hoyt was making his flight a San Francisco business man was driving a well known high powered motor car across the continent to New York City. The car covered 3500 miles in approximately 83 hours by continuous driving with a fuel consumption of about 11 miles per gallon for both machines. There was 18 minutes difference in the elapsed time and laying aside the element of risk that might have been taken in either venture, it is difficult to realize how the driver of the motor car or his assistant could have enjoyed the trip as much or could have felt prepared for a day at the office after the finish, as did the airplane travelers.



THE PRATT AND WHITNEY ENGINE INSTALLED
This new air cooled engine of 400 H.P. is installed in the Wright "Apache" pursuit plane, giving it a climb of 1700 feet in 10 minutes.

### *The Commercial and Light-Plane Races*

Privately owned airplanes constituted the majority of entries in the light commercial airplane race and considerable rivalry existed between the pilots as a number of them had "tricked up" their airplanes and engines in the hope of securing more speed. After the elimination races, final contests for machines powered with engines of 510 cu. in. piston displacement or less, which virtually reduced itself into well known OX motored class, took place. The final race was won at a speed of 107 miles per hour in a Waco airplane which was not without a certain degree of special refinement.

The light airplane races were followed with as much interest as any events on the program. There were four entries which were automatically divided into two groups, those using the Bristol "Cherub" engine of English manufacture or the Wright-Moorehouse, a recently manufactured American engine. The former develops approximately 35 H.P. while the latter 28 H.P. Numerous inquiries were made as to whether the

recently announced Ford "Flivver" airplane was on the field or would arrive for the races. It did not make its appearance and the crowd apparently seemed content to watch the other small machines take off, fly a number of very good races and land with but one mishap which was not serious. The first light-plane race was won by E. B. Heath flying a very neat little monoplane, of his own design, at a speed of 91 M.P.H. The second race was won by A. H. Kreider in a unique low winged monoplane at a speed of 94 M.P.H.

The Speed and Efficiency Race for commercial airplanes was awarded to the airplanes showing the highest speed and the highest figure of merit, the latter based on contest load, speed and engine displacement. The race resolved itself into two groups, those machines which were primarily built for speed and those built to carry a high pay load. The speed element of the contest was won by a local pilot at 136 M.P.H. The efficiency prize was won by the Wright-Bellanca which carried 1292 pounds of pay load at a speed slightly over 121 M.P.H. This airplane also won a second speed and efficiency event and duplicated its performance of the previous year.

One very interesting event in which 12 civilian pilots entered was the precision landing contest. The airplanes were climbed to 1000 feet, the engines stopped and then glided toward the designated line marked in the center of the field. All the machines landed within 25 feet of the mark and the winner stopped 5 feet from the desired spot. It is not always probable that a large landing field is directly below but the accuracy that was displayed on the soft field demonstrated that the pilot can maneuver to a desired spot even though he has no power from the engine.

*The Military Events*

For the first time since the beginning of the National Air Races the famous Pulitzer Trophy Race was not scheduled. Neither the Army nor the Navy desired to enter their racing airplanes this year, therefore, the military speed event was limited to the Free-For-All Pursuit Race. This air classic was a close match and was further intensified by the participation of the best Army, Navy and Marine Corps pilots. Lt. Cuddihy U.S.N. won the event in a Boeing Fighter at a speed of 180 M.P.H. As compared with the tremendous speed of 248 M.P.H., that the late Lt. Bettis made last year in the Pulitzer Race, this speed event might seem slow, however, the winning machine this year was not constructed primarily as a speed creation.

THE BUHL-VERVILLE "AIRSTER"

This is a touring plane and can carry a load of 600 pounds. It is equipped with landing gear, wheel brakes, folding wings, a door to the front cockpit, and is powered with a 200 H.P. Wright "Whirlwind" motor.

The John L. Mitchell Trophy Race, open only to pilots of the First Pursuit Group of the Air Corps, was won by Lt. Elliot in a Curtiss P-1 at 160 M.P.H. Every pilot turned the pylons with the skill of an expert and the precision with which they flew the race was demonstrated by the lap time, which in some instances varied only by tenths of miles per hour. The difference in the time between the winner and the eighth entrant was approximately 3 M.P.H.

The event in which the large bombing and transport machines participated did not seem like a race after witnessing the fast pursuit contest. However, these bombers deceive one for as the race got underway and speeds of 120 M.P.H. were reported the realization of their power and possibilities was better appreciated.

A contest in which observation type airplanes entered was carried out. in the main, by two distinct types of modern observation aircraft. Hardly a moment passed without one of the 12 entries roared around the home pylon with its exhaust drowning out the announcer's voice. A Curtiss Falcon piloted by Lt. Stevens finished first at 142 M.P.H.

Stunt flying competitions were held for Army, Navy and Marine Corps pilots and each branch gave demonstrations that led one to conclude that there were no best but that all the pursuit pilots were excellent, however, the final award was given to the Navy. This was the first year that pursuit machines equipped with radial or V type air cooled engines were seen in open competition with the more familiar water cooled engines. The maneuverability of the radial air cooled engined machines apparently was not hampered as the winning stunt machine was so powered. The Army Air Corps performed excellent night flying and formation flying displays over the Sesqui grounds and the city during the entire meet.

*New Airplanes and Improvements*

Within the aeronautical industry no attempt is made to exhibit the new aircrafts that have been built as is the custom in the automotive industry. The National Air Races serve in part to fulfill this need as at these events most of the recently developed military and commercial airplanes may be seen. This year there appeared for the first time the Wright Apache, a military pursuit machine powered with the new Pratt and Whitney radial air cooled engine. Much discussion has been given to the adaptability of air cooled engines to pursuit flying. The high speed of the Apache was one mile per hour greater than a recent McCook Field version of an Army pursuit machine equipped with

*(Continued on page 204)*

# The Coast and Geodetic Survey*

## *A rather comprehensive study of this very important government service*

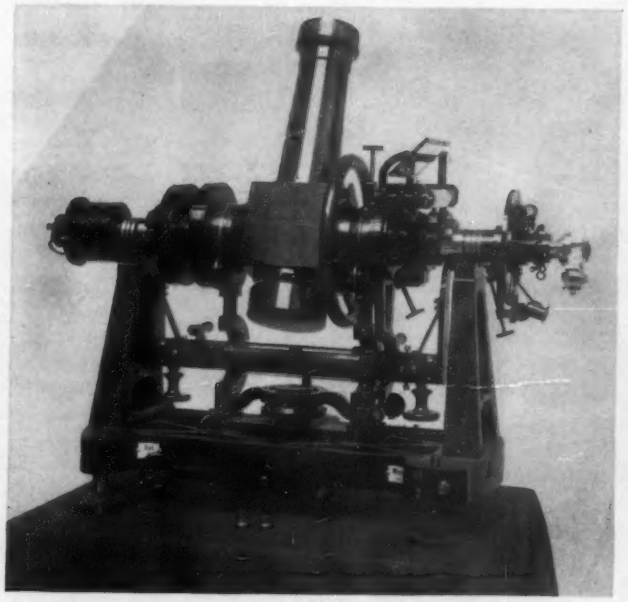
*By* WILLIAM BOWIE
Chief, Division of Geodesy

IT IS the duty of every Government to take stock of the natural resources which are necessary to the welfare of its people. In this country, we have tremendous resources and our Government has for a long time been active in discovering and mapping them. In order that the available means of any country may be inventoried in the best possible manner, we need to know much of the surface of the earth. We need to know the geographic positions of topographic features, their elevations above some datum plane, and the configuration of the ground. Such information is given by what we term a topographic map which shows all topographic features in their proper geographic positions, the elevations of bench marks, tops of ridges, hills and peaks, and by contours the slopes of the ground. Thousands are searching for the hidden treasures of the earth, and these may be water power, soil fertility, and possibilities for irrigation and drainage, as well as minerals, coal and oil.

Not only must a Nation take stock of what it has, but it must provide the means for exchanging the products of its fields, mines and forests and of its factories with goods of other nations which cannot be obtained or so easily produced at home as in other countries. Just after the Revolutionary War and the founding of our Republic, those in charge of the Government realized that charts of our coastal waters were needed for our ever-expanding commerce. It took some years for this thought to crystallize into action. In 1807, under the presidency of Jefferson, the Congress passed an act calling for the charting of our coast and nearby waters. It was not, however, until 1816 that the organization of the new Bureau was completed and field work started. Prior to the organization of the Coast and Geodetic Survey some charting of our harbors and rivers and their approaches from the sea had been made by companies engaged in traffic with Europe, but this was a most unsatisfactory method of doing a public work which was needed by all engaged in shipping. A company making charts for its own use would scarcely be so foolish as to turn those charts over to its competitor.

The Bureau was first organized as the Coast Survey. This name was changed in 1879 to the Coast and Geodetic Survey when we extended our activities into the interior of the country.

The first work of the Coast Survey in the field was the determination of latitude, longitude, and azimuth, and the measurement of a base line and the execution of triangulation on Long Island just east of New York City. New York at that time, as it is now, was the most important seaport of our country. From this beginning, detached surveys and charts were made at a number of places along our coasts. Each chart was based upon an independent determination of the latitude and longitude by observations on the stars.



ASTRONOMIC TRANSIT, BAMBERG BROKEN—TELESCOPE TYPE

It was realized that there should be a strong frame-work for the surveys made along the coasts from which the charts were to be compiled. The plan of using triangulation properly controlled by accurately measured base lines for this purpose was initiated. The triangulation was extended along the coasts from the several astronomic stations. This was satisfactory until the several systems of triangulation were joined; then there were gaps, overlaps, and offsets in the charts at the border line between the two surveys that were being joined. It was early realized that what was needed was continuous triangulation along our coasts based upon some mean astronomic position; then there would be complete harmony among the charts and no chance for confusion in those regions where the charts brought from two directions should overlap.

It is frequently thought that when an astronomic determination of latitude and longitude has been made, that the point is fixed with great accuracy with regard to the initial meridian for longitudes, the one through the observatory at Greenwich, England, and the plane of the equator, which is the reference line for latitudes. It is true that the same value for the latitude and longitude within a very small amount can be reproduced by other instruments and other observers, but there is the troublesome factor called a station error, or deflection of the vertical, which makes it impossible to know the reliability of the astronomic station as a control point for surveys.

As is well known, astronomic observations are all referred to the horizontal plane defined by the level bubbles of the instrument, or, what is the same thing, to the direction of gravity which is at right angles to the horizontal plane through the station where the observations are made. In the case of the Island of Porto Rico there is very deep water in the Atlantic Ocean to the north of the Island, and also very deep water in the Caribbean Sea to the south. The direction of gravity, or what we call the plumb line, is affected by the irregular distribution of masses of the earth's surface. Thus the plumb line at Ponce on the south coast of the Island was pulled to the north by the mass of the Island and the base on which the Island rests, and negatively by the deficiency of the mass in the waters of the Caribbean Sea. Thus the latitude at Ponce as observed was too small—the zenith was deflected to the south.

At San Juan, on the other hand, the Island mass and the deficiency of mass in the Atlantic resulted in the deflection of the plumb line to the south toward the Island and the zenith at the San Juan station was deflected to the north. The resulting

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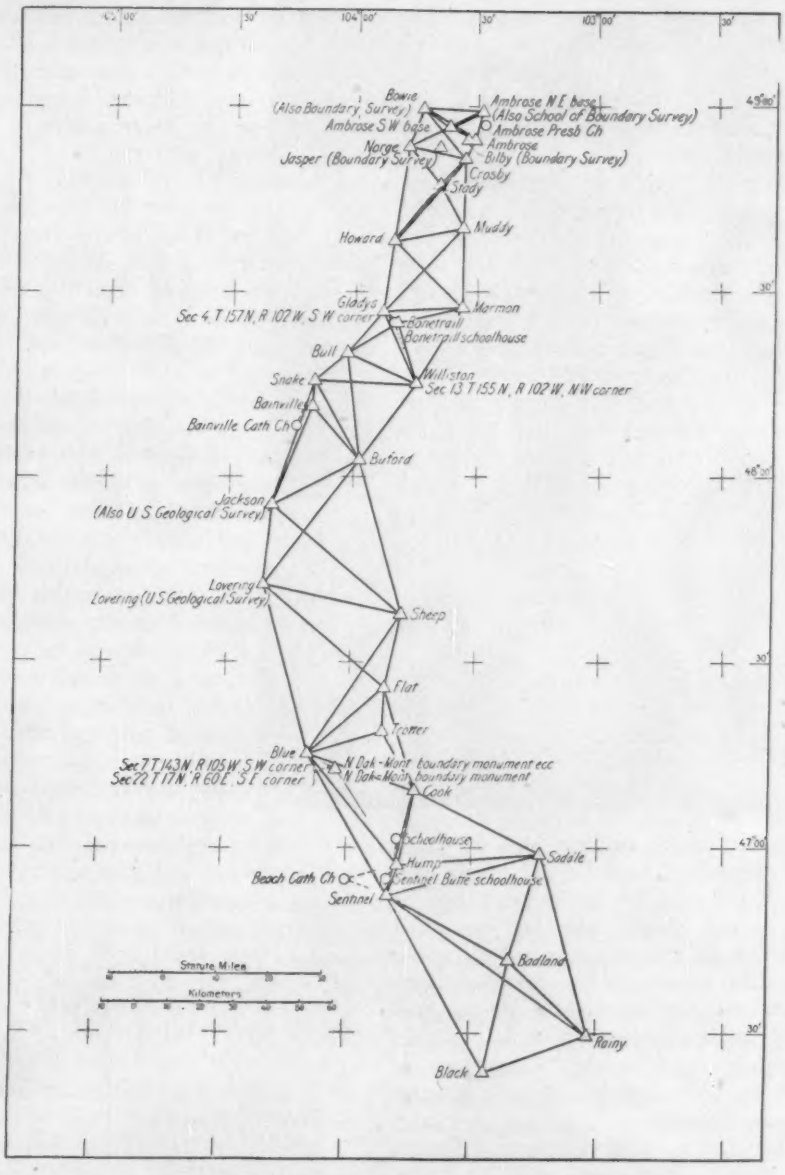
astronomic latitude at San Juan was too great.

The relative error in the latitudes of the two places caused by the relative deflection of the plumb line by 56 seconds meant an error of one mile in the distance between those two places, computed from the difference in latitude, or about one part in thirty-three. One can readily understand that if the charts of Porto Rico were based upon those two astronomic determinations of latitude, the shores at the east and west ends of Porto Rico would have to be elongated or stretched a whole mile, in order that the charts of the south coast and those of the north coast might be joined.

With regard to the case in Asia, there a great valley about 60 miles broad lies between two mountain ridges. An astronomic latitude was observed on the south side of the valley close to the mountains, and another on the north side of the valley. At the southern station the mountain mass to the south deflected the plumb line, throwing the zenith to the north. This resulted in an astronomic latitude that was too great. At the northern station the plumb line was deflected to the north and the zenith thrown to the south. At that station the astronomic latitude was too small. A triangulation connecting these two stations across the valley showed that the sum of the effects of the mountains on the two stations made their relative geographic positions to be in error by 1′ 24″, almost a mile and a half in a distance of about 60 miles between the two stations. It is readily seen from this case that a map of that region could not have been started from each of those two latitude stations with any likelihood of fitting the two parts together.

All this trouble with astronomic determinations of latitude and longitude was obviated by having continuous triangulation connecting the various astronomic stations from which the charts of our coasts were begun. The triangulation was then computed from a single point. That initial point was determined after an inspection of the difference between the geodetic and the astronomic latitudes and longitudes. The latitude and longitude adopted for the initial station were such as to place the whole coast in its most probable position with respect to the equator and the meridian through Greenwich.




ARC OF FIRST-ORDER TRIANGULATION

Not only was it necessary to have triangulation along the coasts to furnish points for the detailed shore line in hydrographic surveys, but it was decided early in the life of the Coast Survey that there should be triangulation of the first order extending along high ground paralleling our Atlantic Coast, where the triangle sides could be of great lengths. At places along the coast, it was impossible to have the triangle sides more than two or three miles in length. With such a small scheme of triangulation, there was likelihood of an accumulation of error in position and direction, but with the large triangles and fewer stations greater strength in the positions and directions could be obtained. At a number of points along this oblique arc which extends from Maine to Mobile, Alabama, along the foothills of the Appalachian Mountains, connections were made to the detailed triangulation along the coast. Similarly, on the western coast of the United States first-order triangulation was carried from the northern boundary of the State of Washington to the southern boundary of the State of California, paralleling the coast with connections made to the detailed coast triangulation.

Some fifty years ago it was realized that the charts of the western coast of the United States should be connected with those of the eastern coast. In order that this might be accomplished, an arc of triangulation was begun in the vicinity of Cape May, N. J., which should extend across the country, following approximately the 39th parallel. This arc was completed in the late 90's and was one of the great arcs of the world

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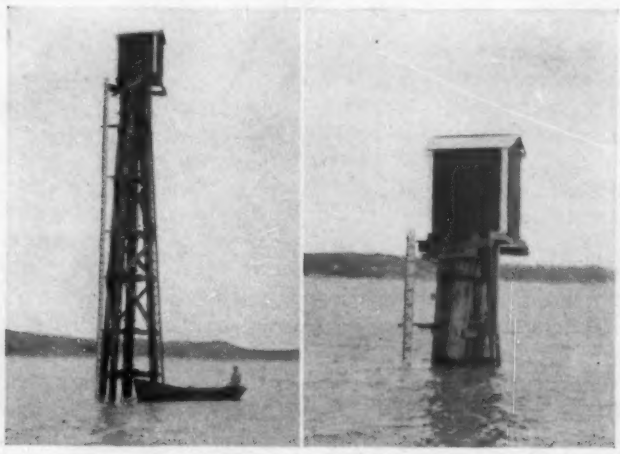
at the time of its completion. This was the beginning of the geodetic work of the Coast and Geodetic Survey in the interior of the country. Up to that time nothing had been done of a geodetic nature except along the coast for charting purposes. This interior triangulation was found to be of such great value in the extension of state and other surveys and maps that Congress decided that the Coast and Geodetic Survey should execute first-order triangulation over the whole country. Of course, not every place would be reached, but such a system was to be carried out that no point in the country would be very far from this first-order triangulation. The intermediate areas could then be covered with second or third order triangulation in order to furnish control points for the topographic engineer and others who might wish to connect in their local surveys.

In connection with the principal continental triangulation it was necessary to have accurate knowledge of elevations in order that the base lines used to control the lengths of the triangulation might be reduced to mean sea level. It is evident that if bases were measured at different levels and not all referred to the same plane or level, there would not be complete harmony in the triangulation joining two such bases. This leveling done to control the length of bases was found to be of great value in railroad surveying and in the extension of topographic mapping over the interior of our country.

The Coast and Geodetic Survey was therefore charged with the continued extension of lines of levels through the interior, connecting the Atlantic, Gulf, and Pacific Coasts. Already we have some 50,000 miles of first-order leveling, most of which has been done by the U. S. Coast and Geodetic Survey. Other organizations which have done some of this work are; the Corps of Engineers of the U. S. Army, in connection with the control and improvement for navigation of some of our large rivers, a few of our railroads, and the U. S. Geological Survey. It is planned to extend the first-order level net to such an extent that no point in the country will be more than about 50 miles from a first-order leveling bench mark. Intermediate areas will be covered with a net work of lines of levels of the second and third order in order to furnish elevations for detailed surveying and engineering operations. In order to complete the first-order leveling net about 40.000 miles more of leveling must be done.

There are now about 19,000 miles of first-order triangulation in the country. In addition to this there are several thousand miles of coast triangulation of what might be called a third order, and much third-order triangulation that has been done by the U. S. Geological Survey, and by the Corps of Engineers in connection with river work for use in detailed surveying and engineering operations. In addition to the triangulation there are 3.000 miles of first-order traverse which is used for correcting geographic positions across country where the land is very level or is heavily wooded, where the erection of triangular towers would be excessively expensive. About 20 000 miles more of first-order triangulation and traverse are needed to complete the first-order scheme of horizontal control.

After a triangulation has been extended along the coast, the engineer locates the shore line by means of the plane table. The plane table has been used in the Coast and Geodetic Survey since the beginning. It was introduced by Hassler. It is now used by the U. S. Geological Survey in all of its topographic work.



TIDE STAFF IN ALASKA AT LOW AND HIGH WATER

Every mile of the coast from Maine to the mouth of the Rio Grande, from Mexico to Canada on the West coast has been gone over at least once by our engineers in making the topographic survey of the shore line. Nothing is left to the imagination. The engineer must see the coast. He has his rodmen give points in every bend and at every projecting point along the shore. These rod readings are taken from the plane table stations and plotted on the plane table sheet right in the field. There can be no mistake made as to just what trend the shore takes. Of course, minute irregularities in the shore line are not indicated, for any sandy shore will change its position a few yards during a single storm. Besides, the charts are printed on comparatively small scales varying from 1:10,000 to 1:1,000,000, and one or two yards on such a scale would be only a fraction of the thickness of a line as drawn on the chart. Prior to 1900 the Coast and Geodetic Survey extended its topographic work back to the nearest railroad or highway paralleling the coast. The purpose of this was to furnish information which would be of value in military operations along the coast, either in defensive or offensive warfare, to furnish navigators with some idea of the configuration of the ground near the shore, and to give the engineers engaged in industrial development some idea as to geographic position, elevation and configuration of the ground. But modern warfare does not limit itself to two or three miles from the shore. Guns are now able to hurl projectiles for twenty or more miles. The navigator is furnished with more aids to navigation than he ever had before, in the form of lighthouses, beacons, lightships and buoys. He does not need so much information in regard to the configuration of the shore as in early days. In addition he now has what is called the radio compass which is installed on every well equipped ship. With this, the navigator can determine his geographic position in stormy weather when not far out from land when observations cannot be made either upon objects on shore or on astronomic objects.

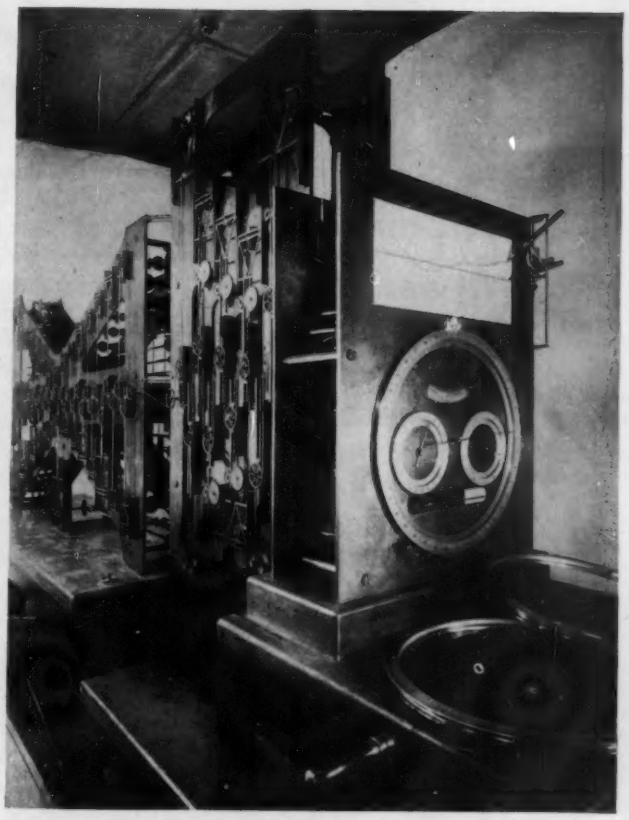
During recent decades the Geological Survey has increased greatly its activities in the making of the topographic map of the country. It now makes the topographic maps even down to the shore line. Therefore, the necessity for having that strip of topography along the shore surveyed by the Coast and Geodetic Survey has ceased to exist. All objects, however, that are close to the shore that might be of value in navigation work, especially large hotels, chimneys of factories, radio stations, prominent cupolas and spires, are located by our engineers and indicated on the chart. When these are identified by the navigator, he can locate himself accurately by taking compass bearings on such objects. Then, too, the engineer engaged on the topographic work along the shores must locate on his plane

table sheet all off-lying rocks and locate in proper position the shore line of any island. This can be done by the plane table method more accurately than by the method used in locating the soundings.

With the triangulation completed and the topographic work along the shores executed, we are then in position to begin the hydrographic surveys. A large sheet of drawing paper is prepared with meridians and parallels and on it are plotted the triangulation stations and the shore line, and all objects which can be easily observed and identified from the vessel or boat working in the water off the shore. The soundings in shoal water are made by the ordinary lead line cast from a row boat or a launch. Two observers with sextants observe the angles between three objects on shore at intervals as the soundings are made. As the two angles have a common side, we can make a graphic solution of the three point problem with what is called the three-arm protractor, thus locating the boat exactly at the time the sextant angles were observed. The soundings usually are equally spaced between the determinations of the position of the boat and so far as is practicable the boat is kept on a straight course between the position determinations. Where it is known that there is a strong current throwing the boat off its course, locations with the sextant angles are made at more frequent intervals.

It is the duty of the Coast and Geodetic Survey to extend its hydrographic surveys well out to sea beyond any area that might have dangers to vessels approaching or leaving our shore. Usually the soundings are carried out to the thousand-fathom depth. Beyond this, experience has shown there are few or no obstructions that would endanger a vessel. In the deep water, the soundings may be taken by specially designed and constructed pressure tubes, or by a wire, to which a heavy weight is attached, running from a reel over a registering sheave, the sheave indicating on its dial the amount of wire that has run out when the sounding is made. The most modern method of making the sounding is by what is called the sonic sounder. This is really a development of processes used during the late war to discover the presence of submarines. All three of these methods are used successfully, although the pressure tube is seldom employed when the depths are more than about 100 fathoms.

When the sounding vessel gets beyond sight of land it must depend for its geographic position upon what is called dead reckoning. The compass gives the direction the ship is travelling and the speed may be derived from the number of turns of the propeller per minute or hour, or by the reading of the log line. But these methods do not give the position of the vessel accurately. Suppose for instance that the soundings are extended for a distance of 50 miles beyond the point where the land can be sighted, and suppose this takes eight hours. There may be an ocean current sweeping along parallel to the coast at the rate of one mile per hour. It may be readily seen that at the end of the fifty-mile run out to sea, which has taken eight hours, the boat may be out of position by eight miles if the current is ignored. We are overcoming that difficulty now by allowing for the effects of currents. In this way the soundings are more accurately located.



TIDE PREDICTING MACHINE

It may be said here that much of the information or rumors that we get about great changes in the bottom of the ocean or of bays which are thought to be due to an actual change in the elevation of the bottom are actually due to erroneous positions. If at the time a sounding is made, the position of the ship as determined is considerably in error, a configuration of the bottom is obtained, especially where the bottom is very broken, which a later and more accurate survey will fail to check. Suppose, for example, the continental shelf is determined by an inaccurate survey, that is, by one where the currents were not determined and where the positions by astronomic observations or by base and log line were not as accurate as they should be. If, later, a very accurate survey were made over the same area, we might have evidence that would lead us to think that the configuration of the bottom had changed hundreds or even thousands of fathoms, while as a matter of fact the difference in the depths of apparently the same places was due to the inaccurate determination of the positions of the ship when the first soundings were made.

The most recent development in the location of a ship beyond sight of land is the radio acoustic method. It would take too long to describe in detail this very ingenious way of locating a ship, but briefly it is to explode a bomb in the water close to the ship. The impulse of this explosion is carried to a recording device on the ship, and is also transmitted through the water to microphones located near the shore which may be 50 or 100 miles away. These microphones connect with radio stations which are actuated by the impulse exerted on the microphones; the resulting radio signals are received on the ship and recorded automatically and compared with the time at which the impulse of the bomb was recorded on the ship. Knowing the velocity of the sound through water, we are able to determine the distance of the ship from each of the two or three microphones on the shore. Those microphones are accurately located by triangulation or other surveying methods. Thus we are able to locate the ship at the time the bomb was exploded. This method has been used only a year or two in the Coast and Geodetic Survey, but it has proved to be most valuable and no doubt further developments will make it even more effective.

The menace of the boulder off the New England coast, the coral head off the coasts of Florida and Porto Rico, and the pinnacle rock of Alaska lead to the development of an apparatus

*(Continued on page 188)*

# Ore Concentration By Flotation

*A short but thorough discussion of the theory and practice involved in this important process*

By A. W. Fahrenwold
Ore Dressing Engineer

THE discovery of the property of the ore minerals, when agitated with water containing a small quantity of an oily substance, to attach themselves, with varying degrees of tenacity, to the air bubbles formed by the agitation and to selectively concentrate in a froth on the surface of the ore-water pulp proved to be the birth of a process that has completely revolutionized methods of ore dressing.

It is about twelve years ago since the first mill in this country was designed and built for concentrating ore by this process. Now there are probably no less than 80,000,000 tons of ore treated by the process yearly.

The property of the various common minerals to show different capacities to adsorb or collect oily substances on their surfaces and to show a selective tendency to attach themselves to and be lifted by bubbles proved to be a difficult one to control when applied in practice. It was difficult for the operator, and for the experienced investigator as well, to understand why two apparently similar ores, when subjected to apparently parallel conditions, with regard to kind and quantity of reagents used, and agitation, etc., gave quite different results. Although now we are able to control the delicate but positive factors involved, to a degree sufficient to make the process applicable and available for the treatment of the sulphide ores, the mystery of the physical or possibly chemical mechanism involved is not entirely absent and the metallurgist, who having tried to develop the theory of the flotation process and then having stood by waiting for the more technically trained physical chemist to show him the light, only to be disappointed, feels no embarrassment over his own past and present inability to understand.

Regarding the theory of flotation space will not permit a discussion that bears the merest pretense of covering the subject. The substances used in the practical present day flotation scheme are of two general classes[1], (1) Organic substances including pine oils, pine tars, hardwood creosotes and coal tar distillates, etc., and (2) Inorganic substances.

Substances of class (1) are frequently among those classed as "non-polar" substances but they lower the surface tension of water and are therefore presumably soluble to some extent for only soluble or partially soluble substances effect the surface tension of water. They are therefore polar to the extent that the molecules have soluble portions or radicals. Wood oils lower the surface tension of water very markedly while the oils derived

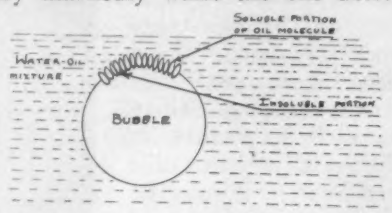



FIGURE 1
Showing arrangement of adsorbed oil molecules at a water-bubble surface.

from the destructive distillation of coal lower it to a less marked degree and are, therefore, presumably less soluble in water than the pine or hardwood oils, Table I. Oils, therefore, since change in surface tension is always accompanied by adsorption, adsorb on the bubble-water surfaces and permit

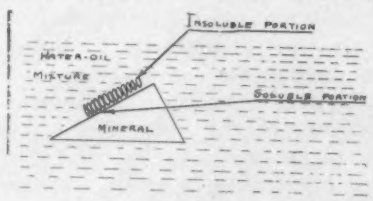



FIGURE 2
Showing a probable arrangement of adsorbed oil molecules at a mineral-water surface.

the building up of a froth. This, then, is one useful function of oil in the flotation process.

TABLE 1
Minimum Surface Tension of Mixtures of Some Common Flotation Oils and Water at 26°C

| | Dynes per centimeter |
|---|---|
| Water | 72.0 |
| Steam distilled pine oil | 43.0 |
| Hardwood creosote | 46.0 |
| Eucalyptus oil | 42.2 |
| Camphor oil | 50.5 |
| Coal tar creosote | 61.0 |
| Oleic Acid | 42.2 |

It should, however, not be understood that the surface tension of the surface of a "freshly" formed bubble in a flotation pulp is of the same magnitude as the surface tension of the "free" surface of the pulp or as the surface tension of the froth formed on top of the pulp. The surface tension of a fresh or newly formed surface such as a skimmed surface or that of a rapidly traveling bubble is little less than that of the pure water.

A small piece of a sulphide mineral placed at the bottom of a breaker containing a solution or mixture of a small amount of a flotation oil in water may be picked up by a freshly formed bubble formed at the end of a capillary tube. The same piece of mineral shows less friendliness to a bubble of greater age. Low bubble surface tension seems then to be not desirable for best flotation. Too much oil in flotation or "over-oiling" gives low bubble surface tension and poor flotation results, because it destroys the selectivity of bubbles for mineral particles.

Experiments[2] seem to have shown that minerals adsorb, or collect on their surfaces, oil molecules or possibly small oil droplets and the amount adsorbed or collected at the mineral-water surface appears to be dependent upon the chemical composition and crystal structure of the mineral. The difference in the capacity of the various common minerals to collect oil appears definitely to bear a relation to the ease with which bubbles, introduced into the pulp, pick up and carry mineral particles to the surface of the pulp. In the case of gangue minerals, quartz for example, and the sulphide minerals, galena for example, the property to collect or adsorb oil and attach to air bubbles is of such wide difference as to permit a selective flotation of the sulphide minerals from the gangue minerals. However, in the case of the sulphide minerals themselves the difference in this property, while reasonably marked, is not ordinarily sufficient to permit the sharp separation by flotation required in practice. It is, therefore, to cause a more marked difference in oil collection and bubble attachment capacity between such minerals that the substances of class II, always strongly polar substances, are used in flotation.

It has been shown by experiments that oil molecules capable of lowering the surface tension of water are composed of portions or atomic groups of unequal solubility. This unequal solubility of the various atomic groups composing the molecule results in a

[1] "Present status of Differential Flotation" Reports of Investigations, U. S. Bureau of Mines. Serial No. 2700, Dept. of Commerce —Bureau of Mines.

[2] "Surface Reaction in Flotation" A.J.M.M.E Vol. LXX—647-736—1924.

definite orientation of the molecule on the water's surface. The soluble end or portion of the molecule is drawn into the water while the insoluble portion is rejected and exposed to the surface. This reasoning points to an orientated arrangement of oil molecules adsorbed at a bubble-water interface. Fig. 1 is intended to indicate graphically the arrangement of adsorbed oil molecules at the water-air (bubble) interface. For example the molecule may be one of the formic acid series, in which case the soluble hydroxyl, (OH), groups are drawn into the body of the water while the insoluble methyl, ($CH_3$), groups point outward and are at the surface.

There is no definite experimental evidence as to the nature of the adsorption of oil at solid-water interfaces but in view of the orientated arrangement of molecules known to exist at water-air interfaces and at liquid-liquid interfaces it is reasonable to assume that the arrangement of oil molecules adsorbed at the mineral-water interface also is orientated. If the adsorption on the mineral surface is of such a nature that the water-insoluble portion of the oil molecule "sticks" into the water while the water soluble portion attaches itself to the mineral surface as shown in Fig. 2, the explanation of the attachment of the mineral particle to the bubble would not be difficult. The particle simply would be engulfed by the bubble, see Fig. 3, similar to the floating of a piece of paraffin on a water-air surface. The magnitude of the tendency of the air to displace water at the oiled mineral-surface or in other words the force of the air-water interfacial tension would readily take hold of the particle. If the oil molecules are attached to the mineral surface in the reverse order, Fig. 4, the attachment, if there would be any, of the mineral particle to the air bubble is not so easily explained. Perhaps the degree of orientation of the adsorbed oil molecules on the mineral-water surfaces is different for the various minerals and perhaps the value of substances of class II, in differential flotation, is due to the effect that these ionized substances have upon the orientation of the oil molecules adsorbed on the mineral surfaces?

Experiments show definitely that adsorption and orientation of oil molecules at a water-air surface is materially affected by the presence of various ions in the water. Also, while experimentally, there is not the volume of reliable evidence, the adsorptive capacity of various solid substances for oil is altered by the presence, in solution, of various ions.

A definite theory as to how flotation works is needed. To say that the value of the addition of a certain chemical to a flotation pulp is caused by a chemical reaction resulting in a selective "coating" of the mineral surfaces due to the formation of a new chemical compound—is insufficient. It may be and no doubt is true that selective mineral surface "coating" is brought about by the use of certain chemicals and that the normal order of floatability of the respec-

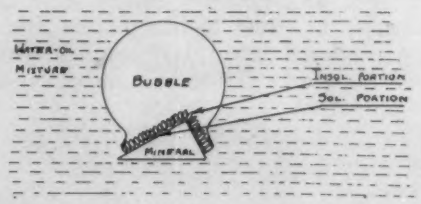



FIGURE 3
Showing nature of attachment of an oiled mineral particle to a bubble.

tive minerals has been changed—but we still have to account for the new relative floatability for the same reason we have been striving to account for the natural relative floatability of quartz and galena or any other minerals.

From the writer's study and obser-

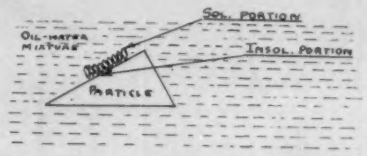



FIGURE 4
Showing improbable arrangement of adsorbed oil molecules at a mineral-water surface.

vations of ore flotation he believes that the following conditions exist and are required for successful flotation, (1) A low surface tension of the liquid film forming the net-work of bubbles in the froth. (2) A high bubble-pulp surface tension, i.e., when the bubble is in the body of the pulp its surface tension should be high—nearly the same as pure water. (3) A large contact angle between water (water of the ore pulp) and the solid to be floated and a low contact angle between water and the solid desired not to float.

Substances of class I, discussed above, fulfill requirement No. 1 and if not used in too large amounts do not interfere with requirement No. 2. They act selectively to promote requirement No. 3. Substances of class II do not interfere with requirements No.'s 1 and 2 but they do promote requirement No. 3. Just how they do this remains to be fully explained.

The rapid development of the art of flotation is due to the persistent and untiring efforts of many individuals, schools, government bureaus, and particularly to the companies who have been confronted with the necessity of turning, for their source of ore supply, to the large deposits of complex sulphide ores that have for years resisted the ordinary methods of ore dressing. Experience soon taught that for best metallurgical results it was necessary to control carefully such factors as (1) the fineness of the grinding, (2) the pulp density, (3) the quantity of oils and reagents added to the pulp, (4) the time of "conditioning" the pulp with the reagents, and (5) the nature of the agitation and aeration of the conditioned pulp.

It can be said that one of the reasons for the failure of much of the earlier practice to give the recoveries and grade of products desired, was definitely due to insufficient grinding to unlock the gangue minerals from the ore minerals, and the ore minerals, in case two or more were present, one from another. In many of the differential flotation plants operating today the ore is ground so that eighty per cent of it will pass a 200 mesh screen.

The improvement in grinding is largely due to improvement in classification. The necessity for finer grinding called for classifiers having larger settling area to permit of sufficient time for the smaller particles to settle and to cope with the remendously large capacities now handled in many of the mills. The Dorr Bowl classifier met with success the new requirement.

It must, however, be pointed out that continued grinding of the ore particles, after liberation of the respective minerals has been effected, is not only not necessary, but expensive practice. Excessive grinding, beyond what we may term the "economic" liberation points results in (1) low grinding mill capacity, (2) high grinding cost per unit of ore, (3) low flotation machine capacity, and (4) high reagent consumption and poor grade products.

This then places a burden on the classifier operated in closed circuit with the grinding mill. It should return to the ball mill the least possible amount of undersize and at the same time not permit oversize to pass with the overflow to the flotation system. Further requirements imposed on the classifier are: (1) it should give a pulp overflow not too dilute for direct flotation which means that very little water may be used, and (2) it must return a thick (80 to 90 percent solids) sand product to the grinding mill. Even under these restrictions better classification will eventually come.

*(Continued on page 202)*

# Engineering—Legendary Kingdom of Midas

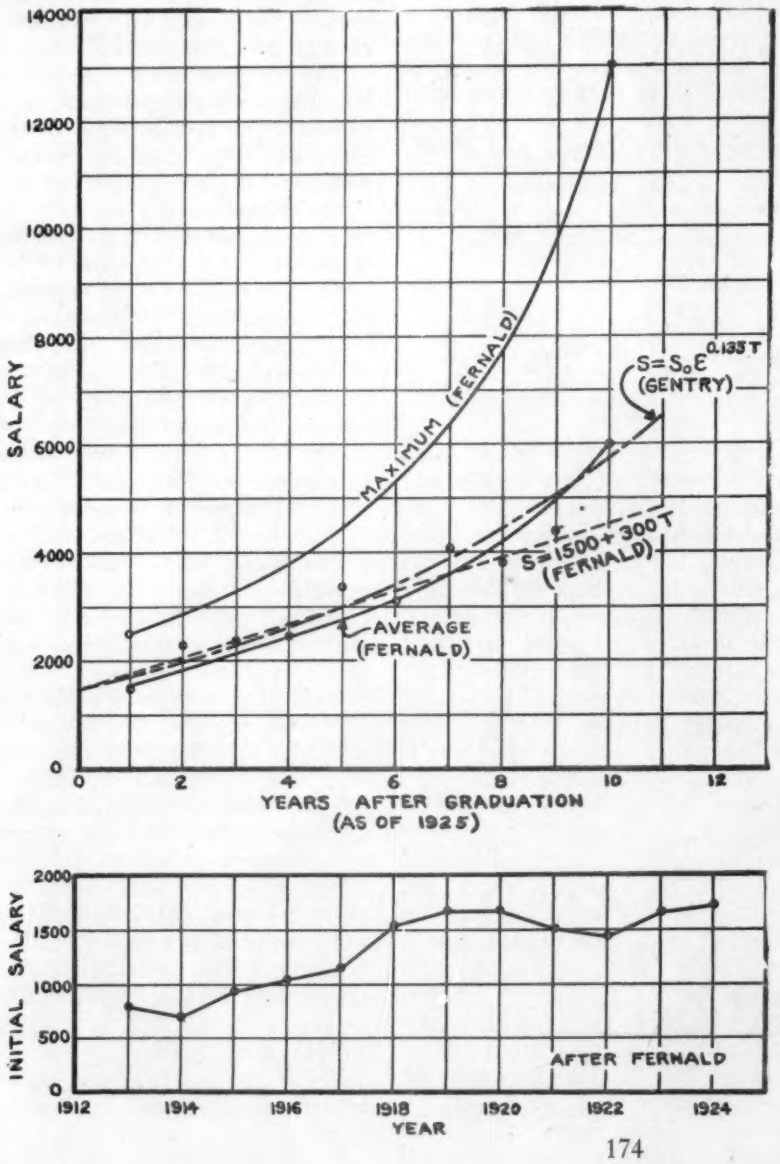
## *Statistical studies of expectations for monetary return on a scientific education*

*By* FRANK M. GENTRY, '23
Assistant to Consulting Engineer, New York Edison Co.

JUST six years ago, when he entered the Institute, the author confronted several heads of departments with the question, "What does the average graduate of your course earn five years after graduation?" There are always two classic answers to embarrassing questions, one doesn't know, or it depends on circumstances. And so at every inquiry, the answer was, either that they had no records or else that it depended on the student! Yes, and it depends on other things too; your employer, the economic state of industry, supply and demand and professional friendships.

To the serious student of engineering, the getting of a technical education is a dollars and cents business. And just how much he can afford to borrow, if he is dependent on financing his studies, by aid outside of his own resources, or whether he shall attend a highly recommended school with its relatively high cost, or a lesser known state institution at nominal cost, must in a large measure be weighed against his expectation of future earnings. If he be conservative, he will adjudge his future earning capacity as equal to that of the average obtained from past records with due allowance for economic changes in the country.

Unfortunately, while some information of this character has been obtained by the Institute, it was under promise that the data so obtained were to be kept strictly confidential. Consequently, we must turn our eyes elsewhere and study the records of others. Prof. R. H. Fernald, Director, Mechanical Engineering Department, Towne Scientific School, University of Pennsylvania, has completed a study of 220 graduates which should be of great interest to every student of engineering and the conclusions of which it is the purpose of this article to review.




The accompanying illustration shows graphically in the lower portion, the average initial salaries of these graduates for the years 1913 to 1924, inclusive. The upper curves show the average and maximum salaries reported for various years after graduation reduced to 1925 conditions. The heavy lines are the conclusions of Prof. Fernald while the dots are the results of his data.

It may be said that the salaries here studied do not include inherited or other income apart from earned remuneration. Prof. Fernald found that the average initial salary doubled in the twelve year period studied, and the initial salary as well as the salary growth after graduation showed marked droops during the business depression of 1920.

Just to be funny, let's use a little mathematics on our data. We shall assume that the rate of increase of one's salary is proportional to the salary, then,

$$\frac{ds}{dt} = a\,S$$

and $$\log_e S = aT + C$$

or $$S = b\,E^{aT}.$$

When $T = 0$ we have $S = S_o$, so that,

$$S = S_o\,E^{aT}$$

and from Fernald's data we find by the method of averages that $a = 0.135$ for the normal salary during ten years after graduation. The curve is plotted in the illustration and if you are willing to gamble that your earning power will continue to increase as heretofore you can extrapolate into your old age! Fernald proposed the equation,

$$S = 1500 + 300\,T$$

as the average salary for the first seven years after graduation.

If it cost you around $1000 a year to go to college and you borrowed all

*(Continued on page 194)*

# Abrasives

*A story of the development of artificial abrasives—Some early and modern uses of abrasives and a brief description of artificial abrasive manufacture*

*By* JOHN B. GLAZE, '12
Research Engineer, The Norton Company

THE Great Pyramid Builders undoubtedly used sharpened tools for carving out those huge blocks of stone that still remind us of that early Egyptian civilization. In the Bible and elsewhere in early literature references are made to methods of "smoothing" or "sharpening."

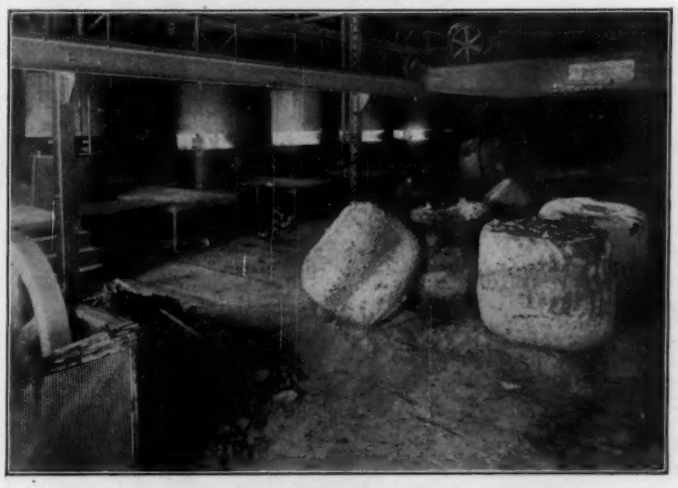
The first accidental production of iron from its ores, long ago, that started the progression toward our civilization, made it necessary for those early users of this metal to sharpen and polish their crude tools and weapon.

There was nothing in the mechanical development of the early centuries that demanded any improvement of grinding methods. The slow moving ox-cart, the sharpened stick for tilling the soil, the slow clumsy water wheel and the application of horsepower did not put the demands upon moving parts that present day machines require. The chief application of abrasive materials—all natural stones—was to sharpen tools for cutting rocks and wood, the principal articles of construction in these engineering feats of the dim past. Sometimes, surfaces were polished, but little attempt was made to fashion any metallic parts with the crude abrasive implements then at hand. As man developed the art of fashioning metal tools, weapons and armour, the same inventive minds replaced the flat stones with a revolving disc or wheel to better aid him in polishing, sharpening and removing metal from his wares.

As man's occupations and trades increased, naturally his demands for comforts and conveniences multiplied. "Necessity is the mother of invention." So man's inventive mind soon developed the printing press, the loom, the steam engine, the threshing machine, the bicycle, the steam-boat, the electric generator, the automobile and the airplane. Such rapid strides forward in the use of all manner of moving parts was made possible by the continually improved grinding wheels and machines that led the way in fabricating these milestones in the advance of modern industry.

So, the sandstone that was dug from the earth gave way to the more efficient materials (emery and corundum) which in turn were replaced by artificial abrasives manufactured in electric furnaces. From these artificial abrasives the modern grinding wheels are made.

The past half century has witnessed more rapid and startling advances in adapting nature's gifts to the service of mankind than all the past centuries combined. Harnessing steam and electricity made the first stages of this advance possible. Up to this point the grinding wheel did not play an important part in actually fashioning the metal parts of machines. But when the metallurgist brought forth alloyed steels and applied each particular quality to the different parts of machines, the demands for more uniform abrasive wheels and more rigid grinding machines to fabricate the tough and hard alloys had to be supplied by the grinding industry. It was then realized that the old familiar lathe, used for so long in all machine shops for turning down soft metals, had its limitations. At this point, the grinding industry stepped to the front and the developments in the last twenty-five years have been a tribute to the untiring efforts and inventive minds of that industry. It was this advance in mastering the hard alloys that made the development of the gas engines, automobiles and airplanes possible. Not one person in a hundred realizes the importance of the grinding industry as applied to every day necessities.



ALUNDUM FURNACE AND PIGS

The grinding wheel in the mind of the layman still remains a tool on which to sharpen a knife or an ax. Few realize that the security of our industrial life rests in the ability of the grinding wheel to meet the heavy demands put upon it by fashioning hard steel parts that are used in all modern machines everywhere. How surprising it is to know that the grinding wheel and machine is not only used for rough grinding or snagging but for the finishing touches on practically all surfaces of moving parts with a precision difficult to imagine,—specifications down to one ten thousandth of an inch are easily met in quantity production.

Grinding has made precision in quantity production possible at low cost.

"Niagara Falls made Detroit possible" is a familiar expression. This implies that, if it were not for the special alloys made in Niagara Falls and if it were not for the artificial abrasives produced by the electric furnaces supplied with power by the mighty cataract of Niagara, the automobile industry of Detroit would not exist on such a large scale. The manufacturers of automobiles today admit that the finished product of their plants would not be possible if it were not for the modern grinding wheels and grinding machines. Without the use of the hard alloys the cars would be twice the size, three times the weight, four times the cost and five times slower than the 1926 models. In fact, an automobile minus the special alloys would be a very unreliable machine and capable of making not much over 50 miles at a stretch.

The automobile is not the only machine affected by the Grinding Industry. Almost every article we use owes its present perfection to the touch of the grinding wheel, either directly or indirectly. As we now use our trusty automobile, in a few years we will be using the airplane as a means of fast

*(Continued on page 176)*

transportation between cities, between home offices and out-lying plants or between the country homes and the city offices. Already the artificial abrasives have mastered the special alloys used by the automotive engineers and made it possible for them to reduce the unit weight of engines to one pound per horsepower.

There are few industries in which the use of the grinding wheel is not an indispensable part. In agriculture wherever implements turn or work the soil, wherever tractors operate or reapers gather crops to feed the world, their edges or moving parts are finished by grinding. The newspaper, which we eagerly scan for our daily news of the world events, is rushed to the streets at a rate undreamed of in the early days of the printer's trade because the moving parts of that complicated automatic machine are ground true by abrasive wheels. And so, we could go down the line of our daily routine duties and pick out the different used articles that we accept as a matter of course, our razor, clothes, well known brands of breakfast foods, knives, tools, saws, paper rolls, electric and steam engines, pullman cars, elevators, typewriters, cash registers, and many other essentials, and know that all owe their present quality and cheapness to the grinding industry.

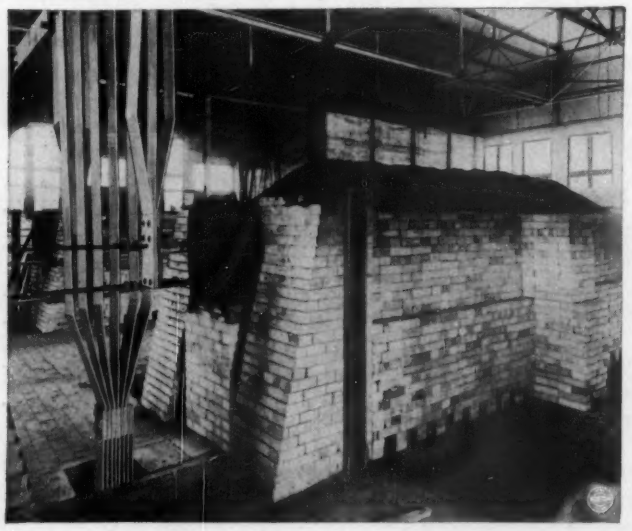
But, let us go back a bit and see how and when the modern abrasive industry received its start and inspiration that has made all these things possible.

Undoubtedly, the first substance used for abrading was the sandstone, which is made up of sharp, reasonably hard particles of sand, usually cemented together with some extraneous material. This sandstone was first used in flat surfaces or slabs, but later the natural stone was rounded out and made into a disc or wheel to be turned on a shaft by hand or foot. This development from the earliest records of polishing or abrading to the use of revolving sandstone wheels covers a period of some 3000 or 4000 years.

A TYPICAL GRINDING ROOM IN AN AUTOMOBILE FACTORY

The next step in the grinding industry was the use of emery and corundum to replace the naturally bonded sandstone. Emery occurs in Turkey, Asia Minor and India and it is reasonable to believe that this abrasive has been used by these people for centuries. The emery or corundum could not be shaped into wheels like sandstone and therefore the uses were limited. Emery owes its abrasive qualities to the crystalline alumina content, which, however, is not very high. Corundum is the purest crystalline form of alumina found in nature. But as it is found in nature it is sometimes difficult to separate it from the surrounding rock. The chief difference, other than purity, between the two natural abrasives is in the size of the crystals of alumina, which are very small in emery and large in corundum.

The art of grinding, as we know it today, started with the manufacture of grinding wheels by artificial means from natural abrasives, and that has been within very recent times. It was about 1837 that the first grinding wheel was made, rubber being used as a binding agent. There was little development of this idea until after the Civil War. Then the Manhattan Rubber Co. of New York made a start by mixing crude rubber with emery and practicing the art of vulcanization with which the world was familiar at that time. The next step in combining emery grains together was in the use of shellac as a binder for manufacturing grinding wheels.



SILICON CARBIDE FURNACE

The real start of our modern grinding industry was the manufacture of a vitrified ceramic wheel in 1879. It was in that year that F. B. Norton with many years experience as a potter conceived the idea of bonding the emery grains with potters' clay. Impure clay and imported emery grains were successfully combined and by 1883 the small potters' plant was producing crude grinding wheels. This act brought into use a bonded abrasive grain far superior as an abrasive than the sand grains of the natural sandstones. It was something practical and at once proved successful. The Norton Emery Wheel Company was incorporated in 1885 to replace the old pottery company.

Emery was used extensively to replace the old-fashioned sandstone wheels. Everything went well until the wheels were used for more accurate work. It was then that the inequalities of emery grains were discovered. A more uniform material was demanded. After using emery from different deposits, it was determined to find a substitute more uniform in quality.

Corundum was tried out but with results similar to emery. The corundum of Georgia, Tennessee, and India were all mixed with impurities from which it was difficult to separate the large crystals.

It must be borne in mind that other materials could not compete with the crystalline alumina of emery and corundum because these crystals presented cutting edges harder than any known substance except the diamond. As the speed of the wheels was increased due to the better artificial bond the grinding wheel was immediately transformed from an abrading tool, or one that rubs off material to an efficient cutting tool, or one that actually cut out chips of material with each contact of the bonded grains. This in itself was a revolutionary change in the principles of the infant grinding industry and a change that

spurred them on to the discovery of more uniform and possibly better or harder abrasives to replace emery and corundum.

About this same time—in the nineties—the electric furnace was being developed. In fact, it was a plaything of many experimenters who were anxious to know what would happen if the extremely high temperatures of the electric arc were applied to all sorts of refractory combinations. This new field was very productive of results not possible before with ordinary gas or coal fired furnaces.

Silicon carbide, SiC, was the first of the present commercial abrasives to be discovered, the inventor being Mr. E. G. Acheson. Five years later, 1895, after quite a struggle a plant was erected at Niagara Falls to produce this material in quantity. This was the start of the Carborundum Co. which is still located at Niagara Falls.

About the same time work had started in France to reproduce emery from a mineral found near a little town called LeBeaux. This ore was oxide of aluminum, $A1_2O_3$, containing considerable amount of impurities. With the aid of the electric furnace some of this ore was fused down and cooled. It was found to be similar to emery.

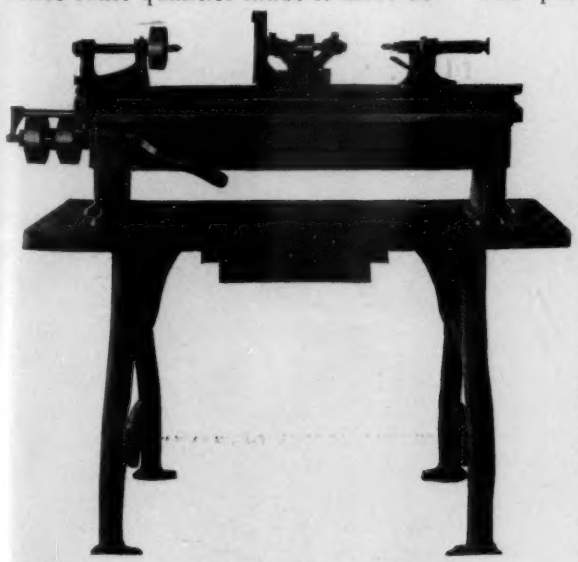
In this country, in 1896, experiments were undertaken by Mr. C. B. Jacobs to reproduce corundum from the same mineral now called bauxite, which was found in this country in quantity and in a purer form than the French ore. This was the beginning of the artificial aluminous abrasives. It was soon learned that the impurities could be reduced and controlled in the electric furnace operation. The crystalline product was superior to emery because it was of higher purity, more uniform in chemical quality and was larger in crystalline structure. These same qualities made it more desirable than corundum. A small plant was first operated at Ampere, N. J., where the original experiments were made. Later in 1897 a plant operated at Rumford Falls, Maine. The Norton Emery Wheel Co. became interested immediately, purchased the patent rights and in 1900 built and operated a plant at Niagara Falls where power contracts were much more favorable than elsewhere.

Briefly, that is the early history of the two leading artificial abrasives now extensively used, silicon carbide and crystalline alumina.

Each has its own particular field for use because of physical characteristics. Silicon carbide is harder—on the scale of hardness—than crystalline alumina, but it is brittle and breaks down readily. For that reason it is used extensively for the softer metals, copper, brass, bronze castings, zinc and similar metals. The aluminous abrasive is used for the heat treated steels, alloy steels and tougher and harder metals because the crystals of alumina are themselves tough and will withstand severe shocks without breaking down. A scheme of determining the correct abrasive to use based on the tensile strength of the materials to be ground has been fairly successful. The silicon carbide abrasives are most efficient with the low tensile strength materials; the aluminous abrasives are best with the high tensile strength materials; while the two abrasives overlap in the middle ground between these extremes in tensile strength.

Not only are the two abrasives different in appearance, hardness and strength but the methods of production are also very dissimilar.

Silicon carbide is a chemical compound formed between very definite temperatures—1850-2250 degrees C., in a resistance type of electric furnace. The purity of the product depends upon the purity of the raw materials used,—coke, sand and sawdust. In other words, no elimination of impurities takes place within the furnace. While the aluminous abrasive is produced by a fusion and purification process carried out simultaneously in an arc furnace. The raw amorphous bauxite ore, which is a clay-like material containing 55 to 60% $A1^2O_3$, is converted to a hard, tough, crystalline product with the $A1_2O_3$ content increased to 95 or 96%.



EARLY TYPE OF GRINDING MACHINE MADE ABOUT 1861

As stated before, silicon carbide was the first artificial abrasive substitute for emery and corundum. It is a beautiful cluster of crystals containing under certain conditions all colors of the rainbow. It is rather difficult to convince most people that such a cluster of colored jewels is made from common coke, sand and sawdust. It is a fact, however, and all that is necessary to do is to apply heat to properly mixed coke, sand and sawdust and iridescent crystals of silicon carbide will be produced. That seems simple enough. Actually, the operation is much more involved. The high purity of silicon carbide depends upon the proper selection of the coke—either pitch coke or petroleum coke, low in ash content—the proper selection of sand, which should be the best grade having at least 99.5% $Si0_2$ content, and a proper grade of hardwood sawdust. These mixture materials are carefully sampled, analyzed and weighed out according to chemical quality of each material. The proportions of sand and coke are based upon the well-known reaction which takes place in this furnace—

A MODERN PRODUCTION—PRECISION GRINDING MACHINE

$$SiO_2 + 3\ C = SiC + 2\ CO$$

The sawdust is added to make the mixture porous and to allow the large quantity of CO gas to escape freely. It is an interesting fact, that for each ton of SiC formed there are 1.39 tons of CO gas liberated. This gas, fortunately, is immediately burned to $CO_2$ at the surface of the furnaces or otherwise the presence of so much poisonous gas around the plant would make working conditions impossible.

The economic production of silicon carbide depends upon several variables, some of which are, size of furnace, rate of power, and total power input, the proper size of core or conducting path through the mixture and the correct proportions of sand, coke and sawdust for the mixture.

The product from the furnaces is easily broken up into small lumps. In this condition it is delivered to the grain department and the crude abrasive is prepared into well-shaped grains. These grains are in turn sold

*(Continued on page 206)*

# The Pictorial Section

## *A description of the fundamental processes in the Iron and Steel Industry*

As the iron and steel industry is the largest and most important of the basic industries, it seems well to devote a few pages to an illustrated description of some of the steps in the production of these metals. Most of our iron ore is found in the Lake Superior region where much of it is mined from open pit mines with steam shovels. The ore as delivered consists of iron oxides and carbonates mixed with small amounts of combined sulphur, phosphorous and manganese with more or less sand and clay and moisture. The iron is obtained from this ore by reduction with carbon in the form of coke. The coke is prepared by heating coal in a retort till the volatile matter has been driven off. The gases leaving the coke are taken to the by-products plant where they are used to furnish a great many valuable substances. Each ton of coal yields about 75% of coke, ten thousand feet of gas, five gallons of tar, twenty-five pounds of ammonium sulphate, one to four gallons of benzol and a small quantity of toluol. An efficient by-products plant will more than pay for the whole coking process. After the coal has been converted into coke the coke is pushed out of the oven as shown in Fig. 1. The coke falls into a car and is taken to a quenching station where it is cooled with cold water.

The first step in the reduction of the ore takes place in the blast furnace shown in Fig. 2. This furnace is charged with a mixture of ore, coke and flux. The blast furnaces are constructed of steel, lined with brick and range from 80 to 100 feet in height and from 18 to 22 feet in diameter. The charge is carried to the top of the furnace by a mechanical conveyor shown at the left of Fig. 2. The charge is placed in the furnace through hoppers so constructed that when the operation is carried out, there is little loss of gas from the furnace.

A blast of highly heated air enters the furnace through pipes called the tuyeres, and rising through the charge converts the carbon near the bottom into carbon dioxide. The latter is subsequently reduced by the hot carbon near it to carbon monoxide, which rises up through the furnace and reduces the oxides of iron. The air for the furnaces is heated in huge stacks, called stoves, shown to the right of the furnace in Fig. 2. They are 100 feet high and over 20 feet in diameter. The interior is filled with open brick work. The gas which issues from the top of the furnace is led to the gas cleaners through a pipe called the "downcomer." This gas contains over 20% of carbon monoxide and possesses a high heat producing value. The greater part of this gas is used in the stoves and the remainder after being freed from dirt, is used in the gas engines as a source of power. The stoves are alternately heated and cooled being used in pairs. The gas is burned in the stove, the heated products of combustion passing through the checker work for an hour or more, heating the bricks to their full heat-absorbing capacity. The gas is then turned off and sent to another stove, while the air blast, supplied by the blowing engines of the blast furnaces, is passed through the heated stove in the opposite direction. The air absorbs the heat from the bricks and then enters the blast furnace at a temperature of from 1000 to 1400 degrees Fahrenheit.

Blast furnaces are run continuously for years, the slag is tapped off through tapping holes at intervals of about two hours and the iron every four or six hours. The slag is treated and used in cement making, for road building, and for other purposes. The molten iron is either converted directly into steel or run into molds and cast into "pigs."

The iron as it leaves the blast furnace must be further refined and made into steel before being used for rails and other industrial uses. The impurities such as phosphorous and sulphur must be removed and the carbon content must be regulated to give the desired qualities for the particular use to which the steel will be put.

The principal process for the conversion of iron into steel is the open hearth process shown in Figs. 3 and 5. In this process a layer of scrap iron is placed on a shallow saucer shaped hearth, enclosed with firebrick and refractories and called a furnace. On this is placed a layer of pig iron and more scrap. Hot gases are forced into the furnace and made to burn alone and around the metals heaped on the hearth. The pig iron runs down over the scrap and a slag forms over the whole surface. The silicon and manganese are first to burn off and then the carbon is changed to gas and burns. This leaves a characterless molten iron which is shown issuing in Figs. 3 and 5 from the furnace. As the metal flows into the ladle weighed quantities of carbon and manganese alloys are added and in the case of alloy steels, vanadium, chromium, tungsten nickel or other alloying elements are added at this stage.

Fig. 4 shows an electric furnace which is used in many plants now to produce steel. The heat for the process is derived from electricity arcs. The chemical reactions are about the same as in the open hearth process. Fig. 6 shows the Bessemer converter which is very widely used in our steel industries. In this process a large steel vessel about 12 feet in diameter and 20 feet high is tipped on its side and molten pig iron is poured into its mouth. A blast of air at a pressure of about 20 lbs. per square inch is turned on at the rate of 20,000 cu. ft. per minute and the converter turned upright. The blast of air going through the hot metal burns out most of the impurities leaving a characterless iron. To this is added the desired amount of carbon and other alloying elements.

After steel of the desired composition has been made by any of the above processes, it is put into ladles and then poured into ingot molds. After the ingots have cooled enough to stand alone, the molds are pulled off by a stripper as shown in Fig. 7. The ingots often weigh about 5000 pounds and are about 18 inches square by 6 feet high. After pouring and removing the ingot from the mold, it is taken to the soaking pits. This is shown in Fig. 8. The soaking pit is a furnace holding from 4 to 8 ingots at a time and kept at a very high temperature for about two hours. By this time the ingot is at an even temperature throughout and ready for rolling.

The yellow hot ingots are then rolled between great steel or cast iron rolls as shown in Figs. 9, 10 and 12. The type of roll used being dependent on the desired shape. Fig. 11 shows the furnace charger which is almost human in its actions. It takes iron and places it in the open hearth furnaces.

This has been a very brief sketch of one of our leading industries but the interested reader should by all means visit a steel mill. In closing, we wish to express our appreciation to the United States Steel Corporation, the Bethlehem Steel Corporation, the Lebanon Steel Corporation and the Ford Motor Co. for permission to use pictures of their plants and equipment in this issue. ADAM K. STRICKER, JR.

FIG 1
PUSHING A COKE OVEN

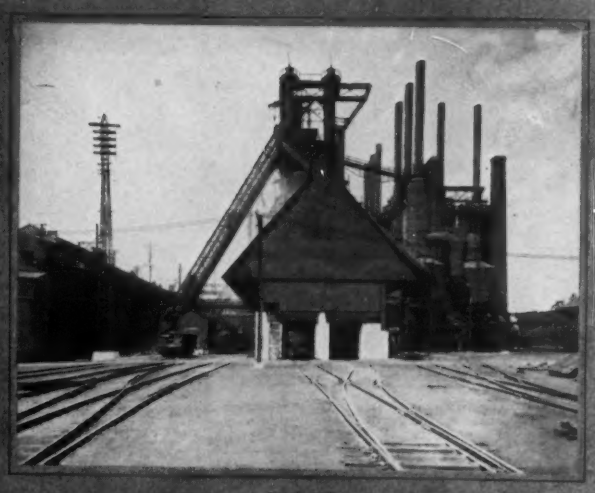


FIG 2
BLAST FURNACE

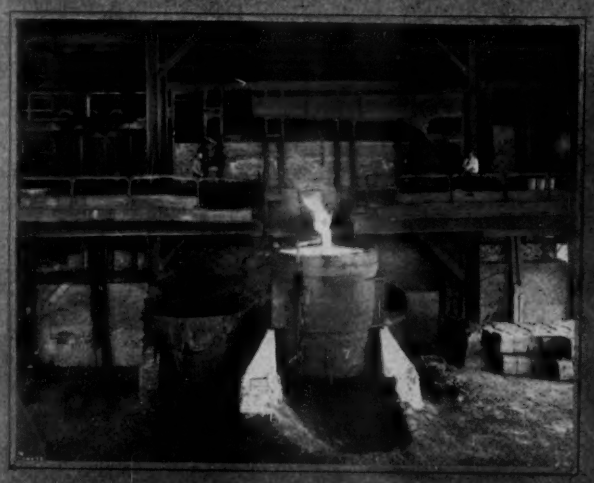


FIG 3
TAPPING OPEN HEARTH FURNACE

FIG 4
POURING ELECTRIC FURNACE

FIG 5
TAPPING OUT

FIG 6
BESSEMER BLOW

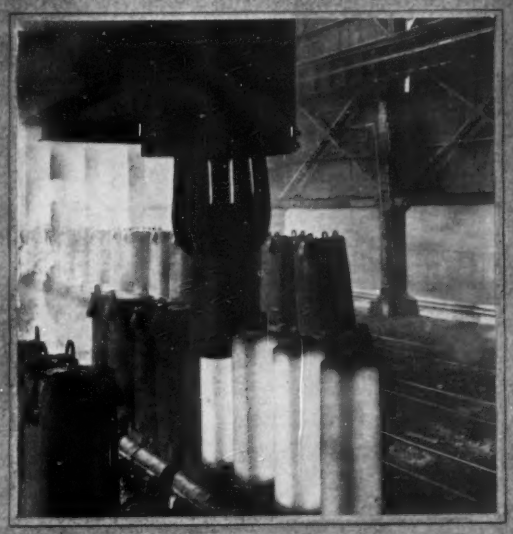


FIG. 7
STRIPPER

FIG. 8
SOAKING PITS

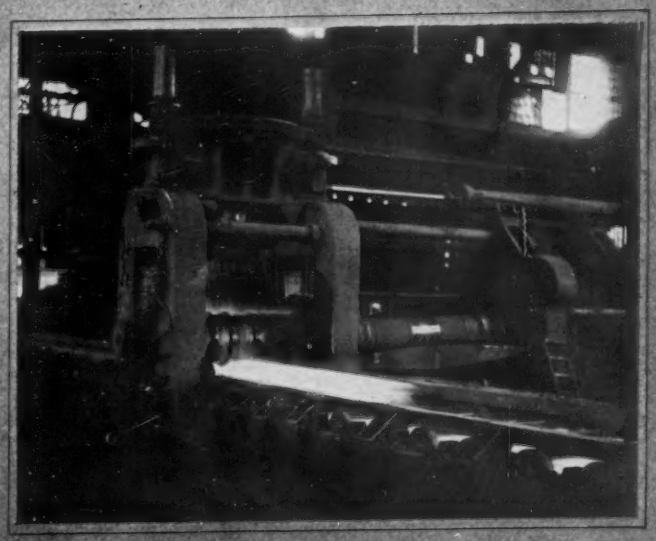


FIG. 9
BLOOMING MILL

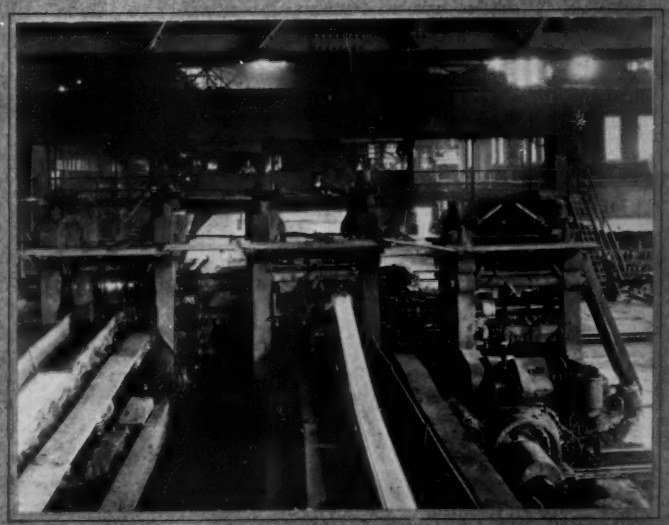


FIG. 10
RAIL MILL

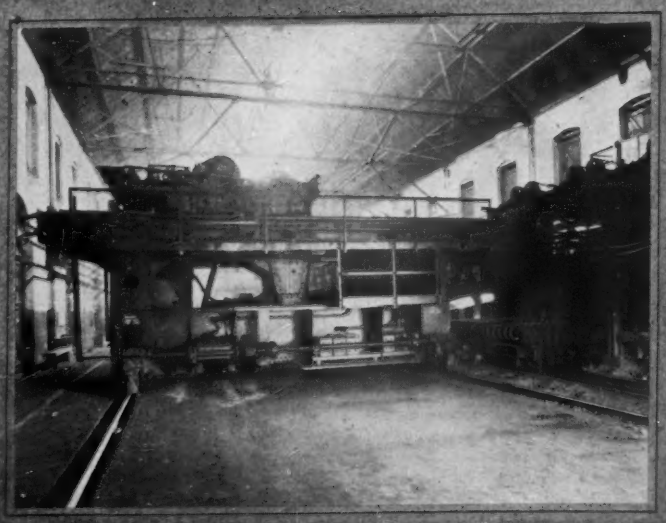


FIG. 11
FURNACE CHARGER

FIG. 12
PLATE MILL

# Editorials

### *EDWARD P. WARNER*

The part that Technology has played in the advancement of the science of Aeronautics has recently received formal recognition and widespread acknowledgment in the form of an honor conferred by the nation upon her leader in that field—the appointment as Assistant Secretary of the Navy in charge of Aeronautics of Professor Edward P. Warner.

Professor Warner received his Master's Degree from Technology in 1917, and ever since has been connected with the Aeronautical Department of the Institute. During this time, he has made the aeronautical studies offered by the Institute of such value that graduate students from everywhere have come to Technology to obtain the latest, most valuable and most reliable information available in that field. The U. S. Army and Navy Air Corps have recruited their finest aeronautical engineers from graduates of Professor Warner's courses. Both have made it a policy to send their aeronautical men here for specialized instruction.

When the infant aeronautical industry, including both manufacture and operation, had grown to a position of importance in the life of the Nation, Technology was fully prepared to add another course to its catalog, Course XVI, Aeronautical Engineering. At its head was placed the man who had so guided Technology's activities in that line that it was possible, when the time came, to group them together into a course of already proved merit.

Meanwhile, Professor Warner has, by increasing study and research, made himself recognized as the foremost authority on the theory of aeronautics, as well as a master of practice. He is admirably fitted to meet the problems confronting him in his new position. We know that he will make most efficient use of all the resources at his command and wish him the best of good luck—especially do we wish him freedom from the meddlesome, devastating hand of Politics—and look forward to his return to the Institute when his work in Washington is done.

---

### *COURSE XVI.*

With our return this year we find a new course, a new line of endeavor, added to our already long list of available undergraduate programs of work. The long mythical Course XVI is at last a reality, offering a complete four year list of subjects leading to a degree in Aeronautical Engineering, and equipping a man with an excellent all-round knowledge of the problems and underlying principles, not only of aircraft design and construction, but also of their operation.

Heretofore work in Aeronautics at the Institute has been open to graduate students only, and it seems especially fitting that this year should mark its expansion. We firmly believe that the past year will stand out as the year marking the end of a long period of transition,—during which aviation has metamorphosed from a "game" to a recognized industry of considerable national importance. Spasmodic government contracts in the past few years have kept open-

### *THE COVER*

*The original of the striking pencil sketch reproduced on the cover of this month's TECH ENGINEERING NEWS is found in a collection of war sketches by Muir Head Bone. It is a drawing of a shipyard as seen from the top of a huge hammer-headed crane—the artist looking downward between the flanges of the jib. The maze of intricate detail is forced to yield the effect of massive significance and the story of steel in industry is told in a single picture.*

aircraft plants alive, so that now the survivors are ready to meet on a sound basis, the five-year steady contracts authorized by Congress last year for the construction of planes for the services.

With the standing of the industry assured and larger capital backing, the industry is sure to expand rapidly with the result that many specially trained men will be required each year. M.I.T., always a leader in all engineering fields, has again anticipated the needs of the country. With a very brilliant record of achievement from her graduate Aeronautic students already, with the finest equipment in the country, and with an exceptionally fine instruction staff the new course is starting under the most favorable auspices and at a most favorable time.

All success to the course and to the men who will graduate from it!

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### *A CORRECTION*

In the article accompanying the Pictorial Section in our May 1926 issue, on page 120, there is an error. In reference to Fig. 11, the weight of the unit is given as 30 tons. This should be 85 tons for the revolving element, bringing the total weight of the mechanism somewhat higher.

In reference to the Gyro-Compass, we have procured some figures. The weight of the rotor wheel is about 50 pounds and its speed is 6000 r.p.m.

### *A NEW FEATURE*

There is a tremendous amount of research going on in the Institute which is original, important and tremendously interesting. Yet no one knows of any of this work unless it is in his own department. Too often only a portion of any department's work is know to anyone other than the department head. This condition has arisen from very definite causes, chief of which is the fact that much of the work is privately financed and the results are private property. Further, there has been no incentive to acquaint others than those primarily concerned with the trend of those endeavors which can be made public until something of value has been accomplished and important results reached.

In the face of this seeming secrecy is a very widespread desire to know what the various research agencies in the Institute are doing. Individual attempts to keep informed are soon discouraged by meeting frequently with a seeming rebuff when the work inquired about proves to be of a confidential nature. In order to make it possible to follow the interesting work and its results, *The Tech Engineering News,* beginning in the next issue, will include a new feature page to be known, perhaps, as Departmental Notes. It will cover the work of three or four departments in each issue, and in time will form a comprehensive survey of the nature of all the research in the Institute that can be published, as well as the social activities of the department. This page will be both interesting reading and very enlightening concerning the scope of the work of the Institute and its relation to industry.

One little incident will serve to illustrate this last point. Users of one type of textile machine are constantly bothered because it is impossible to use oil as a lubricant, and the graphite used in its place soils the thread handled by the machine. The problem was to find a lubricant that would neither damage nor soil. One large user of such machines came to the Institute with the problem. The Chemical Engineering department solved it. The substance evolved replaced the graphite, was white and non-injurious to textile fibres.

This story is short but interesting. As we said before, the Department Notes page will make interesting reading.

# The Engineering Field

*Excerpts from the leading professional and trade journals*

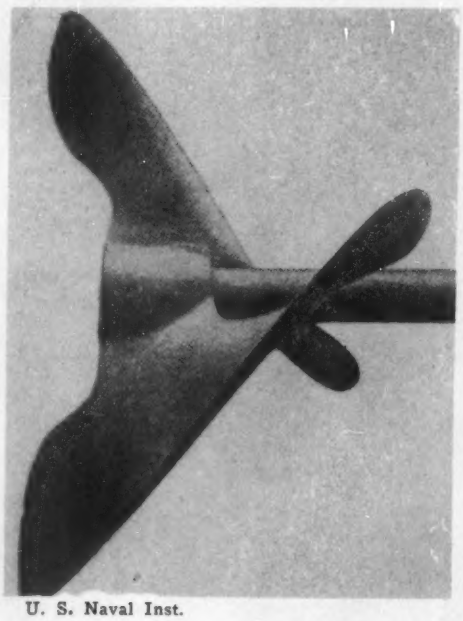
*PREVENTION OF CORROSION* of iron permanently has apparently been made possible by a discovery in Switzerland. The annual loss due to the rusting of iron amounts to millions of dollars. Zinc, tin, nickel, and ordinary lead paint are useful preventives but they do not last.

This new discovery consists of a lead paint which affords a complete and permanent protection to iron. This paint is made by melting lead in an electric furnace and blowing through it air and certain reducing gases, so that a dross or scale is produced which consists of colloidal or extremely finely divided lead dispersed in yellow lead oxide. When it is finely powdered and mixed with specially prepared linseed oil, and applied to an iron surface, very minute particles of lead separate out and gradually penetrate into the surface of the iron. The presence of the lead in the treated iron has been proved by photomicrographs and by chemical analysis. Iron painted with this new paint has not shown any signs of rusting after prolonged exposure, or after being heated in steam.

*A NEW DYE* called "neocyanin" and used for photographing intra-red rays has recently been developed. It will be remembered that the ordinary photographic plate is sensitive only to a very short band of light rays, chiefly those of blue light and the shorter ones of the invisible ultra-violet rays. It can, however, be sensitized to other colors by the use of dyes. The new dye makes them sensitive to light waves of 1/22,000 of an inch, while the longest rays visible to the naked eye are 1/30,000 of an inch.

Plates treated with the new dye may prove a great aid to spectroscopy in the investigation of the infra-red region of stars which hitherto was impossible to do accurately.

*PARACHUTE LANDS PLANE.* Recently a Naval Reserve Pilot took a Jenny plane weighing 1,800 lbs. to an altitude of 2,500 ft. and then after stopping the engine released a giant parachute attached to the plane. The parachute brought both the plane and pilot safely to earth. The descent was at the rate of 38 ft. per sec. and the plane landed three and one half miles west of the starting point.



U. S. Naval Inst.

MAUBLANC-LALLIE MARINE PROPELLER

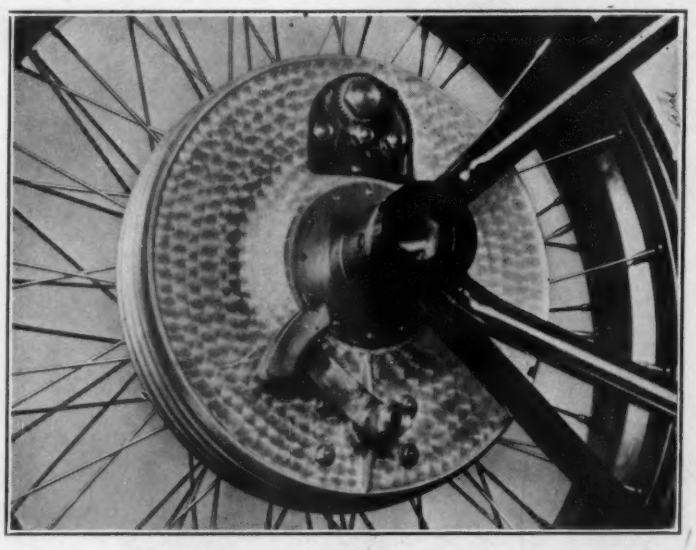
*NEW MARINE PROPELLER*

The Maublanc-Lallie Marine Propeller was designed with the purpose of increasing the effective surface. It has long been known that the portion of the surface of a propeller inclined at 45° to the axis, operates at the maximum efficiency. In order to increase this surface, the propeller had to be given an unusual shape which varies with the conditions under which it is to be used. The shape is such that in rotating it describes a truncated cone.

In operation the wake with this propeller is very narrow which proves that the propulsive effort is exerted along the axis with a minimum of sidewise projection of the liquid.

This new marine propeller has been installed and tested on several vessels previously equipped with ordinary propellers and the substitution has given very gratifying results. On the S. S. Brevin the old four blade propeller 65.3 inches in diameter was replaced by a Maublanc-Lallie three blade propeller 60 inches in diameter. The engines ran the old propeller at 250 r.p.m. while the new propeller at 212 r.p.m. gives the ship the same speed as before. This reduction in the number of revolutions means an economy in fuel and longer life of the engine. The efficiency of the propeller in reversing was shown to be particularly good. Running at full speed ahead a vessel was stopped within one length. Moreover vibration is greatly reduced when this propeller is used. The reduction of the vibration of a 500 ton tugboat was very startling when the conventional propeller was replaced by one of the new type.

*AIRPLANE WHEEL BRAKES.* The first airplane wheel with integral brake has recently been placed on the market and has proved so successful that it has been adopted by many of the leading plane manufacturers. Also the Army Air Corp is making a test of the brakes at McCook Field. The wheel is of light construction with spokes, hub and axle of an alloy composition. The spokes are in three banks, arranged so as to take care of every landing strain. The brake is operated by a wire enclosed in the steel tubing of the landing gear and running to the rudder bar pedals. The brake mechanism is of the self-emerging type and operates with equal force in forward and reverse motion of the wheel.



Copyright Aviation

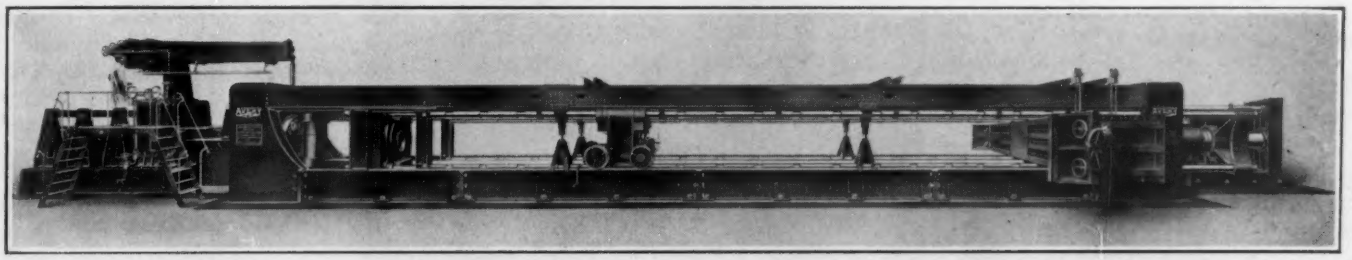
THE SAUZEDDE WHEEL BRAKE

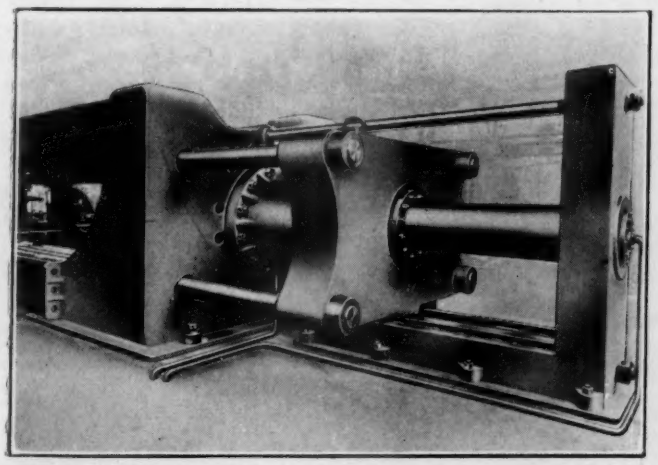
The first successful airplane wheel with integral brake. Note the cooling fins on the drum.

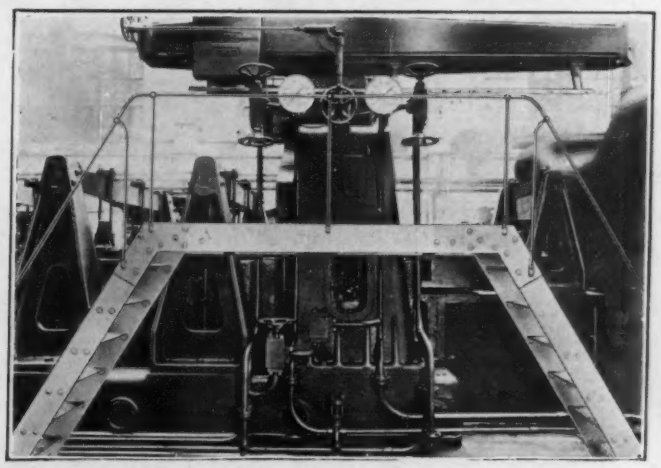
According to tests, brakes decrease the landing roll of planes by two thirds. They are also a great aid to a pilot in enabling him to lock the wheels while he is warming up the engine and to steer his plane about the field and even into the hangar.

*LARGE TESTING MACHINE.* A large universal testing machine has been built for the purpose of testing the structural members and details of the Sydney Harbor arch bridge. This machine of remarkable size is of horizontal arrangement and has a load capacity of 2,800,000 lbs. Its length and internal clearances are sufficient for testing built-up members 50 ft. long and 45 in. square in either tension or compression. For transverse tests, a special crosshead girder will receive members 42 in. thick, of any depth, and 20 ft. in span.

Most of the important parts of the Sydney Harbor bridge will be tested full size in this machine, but it will be necessary to test the largest members in model size.







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HUGE TESTING MACHINE BUILT FOR TESTS OF STRUCTURAL PARTS OF THE SYDNEY HARBOR BRIDGE

Lower views: Left—Hydraulic arrangement for applying loads; Right—Hydraulic and poise weight controls.

This machine uses hydraulic pressure for applying the load. The hydraulic plunger is 32 in. in diameter, has a stroke of 5 1-2 ft., and is copper plated to protect it from corrosion. The plunger is returned by a 20 in. stationary plunger.

The load is measured at the opposite head by means of a lever weighing system. The weighing mechanism has four primary levers, each with knife edges 62 in. long, giving a knife-edge length of nearly 21 ft., proportioning the load on a basis of 5 tons per inch of length. These levers give a reduction of 6 to 1 and are followed by a 5 to 1 bell-crank lever which transmits the pull of the load to the weighing steelyard.

The machine is 120 ft. long over all. All manipulations necessary during a test are made from the operator's stand at the weighing end, where the controlling valves for the hydraulic ram are also located. Operating power is furnished by a battery of high and low pressure accumulators served by two sets of double acting motor-driven pumps.

The United States Bureau of Standards in Washington has an Olsen machine which has a load capacity of 10,000,000 lbs. and can take specimens up to 24 ft. in length, but is fitted for compression tests only. The most powerful tension testing machine in this country is owned by the American Bridge Co. It is used for testing eye-bars and has a capacity of 4,000,000 lbs. and can test bars up to 35 ft. in length.

*AT THE SESQUI-CENTENNIAL* more lavish use has been made of lighting than at any previous affair of this kind. The outstanding lighting feature is the luminous Liberty Bell at the Plaza. It towers eighty feet above the sidewalk and contains over 26,000 fifteen-watt lamps. The structure contains eighty tons of steel and is built on a foundation thirty feet deep, made of wooden piling and concrete capping.

The Tower of Light is 200 feet high and has a 62 inch Sperry searchlight, the largest ever built, mounted on top of it.

Twenty-four searchlights used at the exposition grounds have a combined intensity of 10,800,000 candle power.

*WETTEST SPOT ON EARTH.* The lowest temperature ever recorded on the earth's surface was —90°F. at Verhoyansk in Siberia in January, 1885 and 1892. The record for heavy annual rainfall is held by a planteau northeast of Calcutta at an elevation of 4200 feet. This spot shows annual falls ranging from 427 to 449 inches which is more than ten times that of the average of the eastern United States. At a point in the Hawaiian Islands a fall of 561.86 inches was noted in 1918. The least fall on records for a long period is 1/5 of an inch at Iquiqui in the Chilean nitrate desert. A locality may have very frequent rains and not have an unusually high annual rainfall as witnessed by the fact that at a point in the Marshall Islands, 336 rainy days have been noted in one year. A traveler in the Orinoco basin said that in the dry season it rained every day, and in the wet season all the time.

# Here and There

*Interesting notes from the Editor's desk*

### *A NEW INSULATING MATERIAL*

French technicians have finally perfected this new ceramic, insolantite, on which they have been working since the World War. This material is superior, both electrically and mechanically, to any previously known insulator.

A fine powder through which a current of a certain gas has been passed, is compressed under a pressure of about 25 tons per square inch. This great pressure, together with the catalytic effect causes the powder to coalesce into a solid mass. It can be made into rods with diameters ranging from 1/16″ to 10″ and tubing with either thin or thick walls. The blocks or rods can be machined as easily as brass or soft steel.

After the pieces have been machined, they are fired at a temperature of 2700° Fahrenheit for one minute. This firing makes the material as hard as agate and as tough as cast iron. The threads of a steel screw will be stripped before the threads in a block of isolantite will give way.

This material has a resistance of high frequency of 5 x $10^{15}$ ohms per square cm. of surface and a breakdown resistance of over 30,000 V. per millimeter of thickness. It shows a phase difference of only 6 minutes at the most, compared wtih 26 minutes for hard rubber, and higher values for other insulating materials. Its dielectric constant is only 3.6 at low frequency, and still lower at high frequencies. These characteristics make it very valuable for use in high frequency work such as radio, spark plugs for airplane engines, etc. Isolantite also has a wide chemical application because it is non-porous and will not absorb liquids even though in constant contact with them.

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### *TRADITION*

The old Grecian custom of carrying fire from the homeland to the colonies has been carried out by the Consolidated Gas Company of New York in opening new plants, for over a century. Every time the company has opened a new plant burning coals have been carried from the nearest established plant, not by runner as did the Greeks, but by motor truck, to start the fires in the new ovens. This means that heat is now furnished to make gas in New York City from a coal fire started in 1823. The officials of the company say that tradition will always be carried out.

### *THE COLLEGE MAGAZINE*

The world is full of magazines—I tumble for them all;
The postman opens wide the door and piles them in the hall.
I stumble over Rustic Life when I start off at morn,
And wipe my feet at evening on the Bolshevistic Thorn.
I cannot read the printed stream that riots thru my door,
For I'm too busy striving to increase my worldly store.
I haven't time to masticate this mass of printer's ink,
And if I tried to read it all I'd have no time to think,
I amble gently on my way and let the flood roll by,
But now and then a sparkling sheet attracts my eagle eye.
I fish it out and open it and bless old Cadmus then,
For he has made it possible to print the thoughts of men.
And first among these choicest ones I count the magazine
That comes to me with college news that keeps my memories green.
The college journal that the boys so gravely labor o'er!
They have my full comprendez vous,—I too have done that chore.
I labored early, labored late and drained my thinkpot dry
To get December's issue out e'er June exams rolled by.
I wrestled with our students who were frozen to their pelf,
And pleaded with alumni who were centered all in self.
I rustled ads around the town until the merchants there
Arose in righteous self defense and chased me off the square.
And when I thought I had a bone hid in our treasury,
The printer sent a billet due and took that bone from me.
I thought my efforts would exalt my alma mater dear,
Perhaps so, but the profs. took stock and canned me out that year.
I think of these old college days as each fall rolls around,
And when they ask me to subscribe I'm eager as a hound.
I send that measly dollar bill a kiting on its way,
I know I'll get my money's worth and make some young hearts gay.
I waste a plenty every year, but one investment pays,—
The coin I spend to buy a breath of dear old college days.
The host of famous magazines lies piled up on the floor;
I tear the wrapper from the little piebald two by four.
I read the happenings upon the campus where I used
To hustle up and down with pals and co-eds fair.
From A to Z I read it through, including Eds and Ads,
And then I heave a solemn sigh and say, "God bless them lads."
You, too, my son, will bless them if you'll loosen up your roll
And spend one lone simoleon for tonic for your soul.

### *ENGINEERING AS IT IS*

The "Hazardous Engineering Service, Inc.," has been incorporated in the State of New York. Judging from the experience of a good many who try to practice engineering the name might have universal appeal. Apparently what they are going to do, however, is to sell dyeing and cleaning concerns some machinery. And gasoline, when rubbed on cloth, is hazardous.

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### *THE SINGING FLAME AGAIN*

From England comes a new gas-burning phonograph in which a gas flame is made to reproduce the music. Vibrations from the diaphragm are transmitted to small gas burners attached inside the soundbox and it is said that the music thus produced is of unusual purity—particularly in the case of violin music.

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### *AUTOMATIC ORCHIDS*

The importation of orchid plants into this country is no longer necessary as it has been found possible to grow them here from the seed with proper care and temperature conditions. Automatically controlled gas heat maintains a daytime temperature of 90 degrees F. and a nighttime warmth of 70 degrees F. for a year, at the end of which time the plant is formed and ready for transplanting.

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### *THE DEATH NOISE*

Professors R. A. Wood and A. L. Loomis of Johns Hopkins University have now brought us a supplement to the "death ray"—the "death noise." This "noise" is inaudible to human ears, the waves having a frequency of from 100,000 to 400,000 per second while the limit of audibility to human ears is from 20,000 to 30,000 per second. However, this inaudible "noise," generated by electrical apparatus, when directed in a beam toward the surface of the water, caused the surface to heap up in a mound. The vibrations heat the water, a rise of nearly ten degrees Fahrenheit having been recorded. The sound waves, so directed, killed small fishes and other aquatic animals in vessels of water in less than a minute.

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# Recent Books

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**Diesel Engines (Marine, Locomotive, Stationary). By David Louis Jones, Chief Machinist, U. S. Navy. New York: Norman Henley Publishing Co. 1926. Illustrated.**

The author of this book has tried to avoid the fault of most books on Diesel engines in plunging too deeply into thermodynamics and theory. To this end he has limited the scope of this work to the elementary principles, care and operation of the Diesel engine, for the practical operating engineer. The author devotes a short chapter to an elementary discussion of thermodynamics which illustrates chiefly the fundamental thermal principle of the Diesel cycle. Reference to this chapter, so far as the employment of symbols is concerned is made in only two subsequent chapters. Nevertheless, the theory of operation is not lost sight of as the author is careful to explain both why and how the various parts function.

A chapter on "Elementary Principles" effects a good transition from theory to practice and should be easy for the beginner to understand. Following this is a chapter on efficiencies which compares the Diesel with steam turbine installation. Next is a description of constructional details as developed by various manufacturers. Separate chapters treat with considerable detail such parts as spray valves, fuel pumps, fuel systems, governors and valve gears. Various features of their construction and operation are shown by plates, sketches and diagrams which make the functions of these important parts entirely clear.

Engine testing is touched on only in a general way, though there is a chapter on indicator cards and testing which may be helpful to the operator who is trouble-hunting by the indicator method or is trying to improve general efficiency. A chapter on the "Operation of Diesel Engines" explains the steps to be taken in starting, running and stopping a typical plant, and includes some common derangements with their correct remedies.

Detailed descriptions of various representative types of Diesel engines are contained in some 350 pages of the book.

The advantages of Diesel-electric drive over equivalent steam drive are brought out forcibly. The detail and operation of the electric end of this drive is dealt with at length. A chapter follows which treats of the application of this type of drive to locomotives.

The volume is concluded with chapters treating on the properties of lubricating and fuel oils, marine rules applying to Diesel construction and a set of "pointers" for the operator. It is a book for the practical man who wishes to know both "why" and "how" and is elementary enough for the beginner and sufficiently advanced for those who have had Diesel engine experience.

**A Treatise on Hydraulics. By Hector J. Hughes, A.B., B.S., Dean of the Engineering School, Harvard University; and Arthur T. Safford, A.M., A.S.C.E., A.S.M.E. New York: The Macmillan Co., 1926. 360 pp.**

This is a most complete work on practical hydraulics. It contains the most trustworthy information available on the subject presented in a most logical and convenient form.

The material presented has been confined to the fields of water flow and its measurement, water pressure and the stability of simple structures presented to it, and the basic principles of water motors. The discussion of nozzles is made most complete by the inclusion and treatment of many formulas and tables.

Chapter XIII, on weirs, is perhaps the most valuable part of the whole book. The student can turn to this source for the most valuable information and complete data and formulas pertaining to the most accepted methods of weir measurements. In the next chapter another popular method of stream gauging—float and current meter measurements—is given a brief resume. Chapter XV, on flow of water in pipes and conduits is similar to Chapter XIII in that it furnishes a large amount of collated data on flow in pipes and open channels, well presented in convenient form. The last two chapters consider briefly the dynamic action of flowing water, water wheels and pumps. There is an appendix which contains material of exceptional value for expediting the solution of problems both for the practical man and the student.

This book makes an excellent supplement to the usual text on hydraulics and it is to be highly recommended to the student and to the pacticing engineer.

**Fuels and Their Combustion. By Robert T. Haslam and Robert P. Russell, Professor and Assistant Professor, respectively, of Chemical Engineering, Massachusetts Institute of Technology, 809 pp. McGraw-Hill Book Company, Inc., New York. 1926.**

Technical books generally fall in one of two classes: either they are suitable for use as college textbooks; or they are best fitted for use as reference works or guides for men in industry. The present work, although said to be based on a lecture course given at M. I. T., plainly falls into the latter class. Its scope is so very broad and it deals in such a comprehensive way with its subject that it is hard to imagine it used as a text except in a course in which the aim was to prepare combustion specialists.

For the user of fuels, the man in the plant, this book should prove of highest value. It covers the subjects of coal, petroleum, and gaseous fuels completely, their origin, preparation and use being simply but well brought out. The chemical and physical bases of combustion are treated and some 68 pp. devoted to the important topic of combustion calculations. Several long chapters are devoted to furnaces and other combustion devices. Furnace efficiency, heat losses and methods of figuring heat balances are fully treated. Those unit processes of chemical engineering that are closely bound up to combustion—flow of fluids and heat transfer—receive due notice. And finally, although the reason for this inclusion is hardly clear, some 150 pp. are devoted to an account of the manufacture of producer gas, water gas and oil gas, and to the carbonization of coal.

As intimated, this work is a veritable cyclopedia for the fuel user. In addition, the information on the various topics is sound, up-to-date and concise. Much praise is due the authors for the way in which they have gathered their facts together and compiled them. All things considered, this work appears to be the most useful so far produced for those who use fuels and combustion processes. It is earnestly recommended to their attention.

G. L. Montgomery *in Chem. & Met. Eng.*

**Roman Architecture. By G. T. Rivoira. Translated by G. McN. Rushforth. Oxford University Press, 1925. Illustrated.**

This work is the last of a great student of the evolution of architecture. It was published in 1921, after his death, and translated to the English and published in 1925. *Roman Architecture* deals with the architecture of Imperial times, from the end of the Republic to the fall of the Western Empire. Its main thesis is a development of the theory that Roman architecture has wielded the predominating influence in the development of the later architecture of the Mediterranean.

The book exhibits an extraordinary amount of independent personal judgment and observation. The author has endeavored to see and prove for himself wherever possible, never content with merely second hand opinions. The greatest and best-known examples of Roman architecture are treated in detail, while innumerable lesser buildings are discussed and illustrated, with especial attention given to those containing arches, semi-cycles, vaults and domes. The book contains a wealth of carefully analyzed material not to be found elsewhere relating to the development of these forms of construction and their relation to the materials used by the Roman builders. There are more than 350 illustrations, nearly all new, comprising a detailed review of the progress of Roman construction. Diagrams are accompanied by photographs of an existing example. Drawings by artists such as Palladio and Carmina show the ingenuity of the Roman builder in construction and experiment and the thoroughness with which Renaissance architects studied all available remains of the Classical Age.

**Methods of Measuring Temperature. By Ezer Griffiths, D. Sc., Principal Assistant in the Physics Department of the National Physical Labratory. Second edition revised. 203 pages, illustrated; Philadelphia, J. B. Lippincott Company, 1925.**

This volume describes and analyzes the details of the methods of measuring temperatures over a wide range to the fine degree of accuracy necessitated by modern requirements. The first four chapters comprise nearly half the book. The first is a general account of the method of determining the fundamental scale of temperature. There is outlined, along with references to the boiling point of sulphur, the calibration of mercurial, gas and resistance thermometers covering a total temperature range of from 200°C. to 1500°C. The second chapter deals with the technique of the calibration of mercurial thermometers and the third with resistance thermometers and approved forms of resistance bridges. The fourth deals with thermocouple thermometers. Succeeding chapters relate to the laws of radiation and to radiation pyrometers. The "fourth power" law is reviewed. Following this are accounts of types of radiation pyrometers, then a treatment of radiation from oxide and metallic surfaces, the distribution of energy in the heat-emission spectrum of a "full radiator" and of the metals, the principles of optical pyrometry and, finally, the determination of high-temperature melting points. Splendid lists of bibliographical references are at the end of each chapter.

The volume contains a great deal of analytical discussion, but its strongest appeal is to the experimental investigator.

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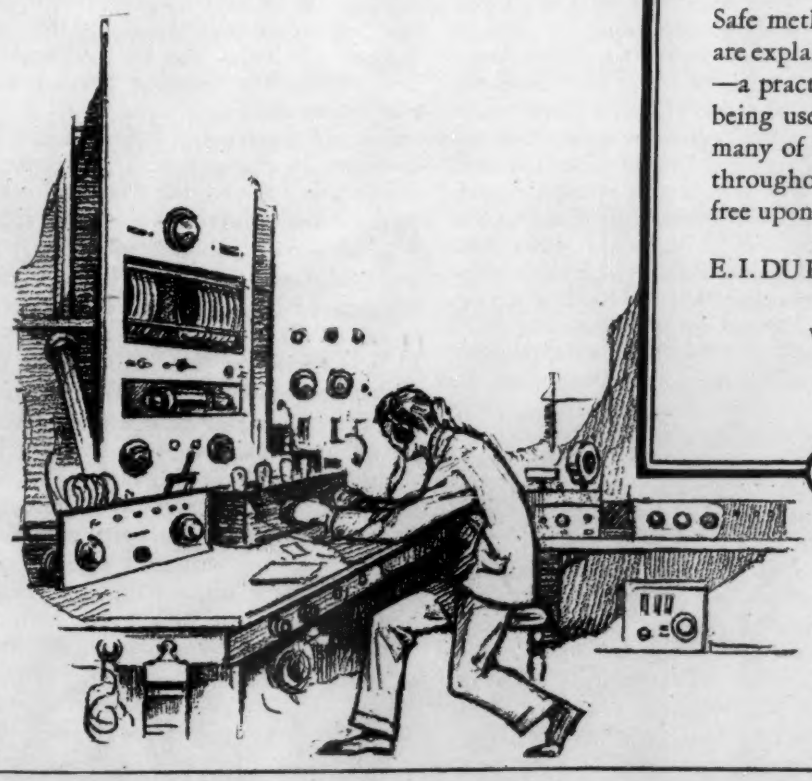

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123 YEARS OF LEADERSHIP IN THE SERVICE OF INDUSTRY

# The Coast and Geodetic Survey

*(Continued from page 171)*

which has proved effective in discovering those objects of small horizontal extent which have escaped detection by the lead line and other sounding devices. The apparatus is called the wire drag or the wire sweep. It consists essentially of a small wire cable suspended at a certain depth below the water surface. It is held in position by weights suspended from floats. The wire cable is dragged through the water by means of two launches working somewhat against each other to keep the line taut. Whenever a depth of water less than the depth to which the wire is placed is encountered, an angle is formed in the floats supporting the wire, and if the obstruction is a wreck, a pinnacle rock, coral head or a boulder, naturally the wire holds and stops the towing launches. In such a case, a temporary float is anchored near the obstruction. A special wire drag of short length is then used to detect the exact depth of water over the obstruction. If the obstruction is in water frequented by vessels, a telegram is sent by the field engineer to the Washington office of the Survey, the Director of the Lighthouse Service is notified and a buoy is placed at the obstruction to warn mariners. Notices to mariners are sent out through newspapers and special publications telling of the finding of the new danger. The wire drag was first used by the Coast and Geodetic Survey in 1904 and it is certain that during the interval since then many wrecks have been prevented by the discovery and charting of these isolated obstructions.

The Coast and Geodetic Survey is studying the tidal phenomenon from a scientific standpoint, as well as to get observations for reducing the soundings. For this purpose a number of permanent tide gauges have been established along our coasts, the coasts of Alaska, and in the Philippine Islands, in order to determine any periodic variation in the position of what we call mean sea level, the plane to which all elevations used for land surveying and for engineering purposes, are or should be referred. In addition, these primary stations furnish tidal control for surveys carried on within the area of which they are representative.

There are currents along our coasts, lack of knowledge of which might lead to great disasters to ships. Many vessels have been stranded on the coast in thick weather owing to lack of knowledge of the drift of the water or what we call ocean currents. This condition is being met by the Coast and Geodetic Survey which has a special appropriation from Congress to make current observations and prepare tables of currents, thus making it possible to give warning to navigators.

The magnetic work of the Coast and Geodetic Survey has developed to meet the needs of the navigator and the surveyor. Every vessel of every description is equipped with one or more compasses and the compass is the guide of the navigator when no landmarks or heavenly bodies are visible. Unfortunately the compass needle does not, in general, point true north, nor is its direction at any particular place constant. In the United States, for instance, the compass needle points 22° west of true north in northeastern Maine and 25° east of true north in northwestern Washington. In Maine it now points as much as 8° more to the west than it did 150 years ago. It is evident therefore that a knowledge of the compass variation is indispensable to the navigator.

To meet these and other needs, the Coast and Geodetic Survey has made magnetic observations at thousands of places throughout the country and some over the adjacent water areas; it repeats these observations at intervals of about five years at a sufficient number of places to determine the change of the earth's magnetism with lapse of time; and it operates five magnetic observatories, at which a continuous photographic record is secured of all the fluctuations in the direction and intensity of the earth's magnetic field.

All of the triangulation, topographic, hydrographic, current and base data collected in the field are placed on the chart, in order that the navigator may have complete information, but it is frequently the case that aids to navigation other than the chart must be furnished him. For instance, there are the lightships stationed along the coasts, furnishing the mariner fixed points of departure and "landfalls" visible at night in making a dangerous coast.

But even with all the information furnished the navigator by the Coast and Geodetic Survey and the Lighthouse Service, there are unavoidable dangers he must face. The accuracy of the determination of his position becomes uncertain in stormy weather. His ship may become unmanageable from accident to rudder or propeller, or the carrying away of sails and masts. In cases of accident the S O S is responded to by the cutters of the Coast Guard Service which are always ready when that alarming signal is received.

Thus we have three great Government services, the U. S. Coast and Geodetic Survey, the U. S. Lighthouse Service, and the U. S. Coast Guard Service, all working together in the utmost harmony and with great efficiency to make navigation safer.

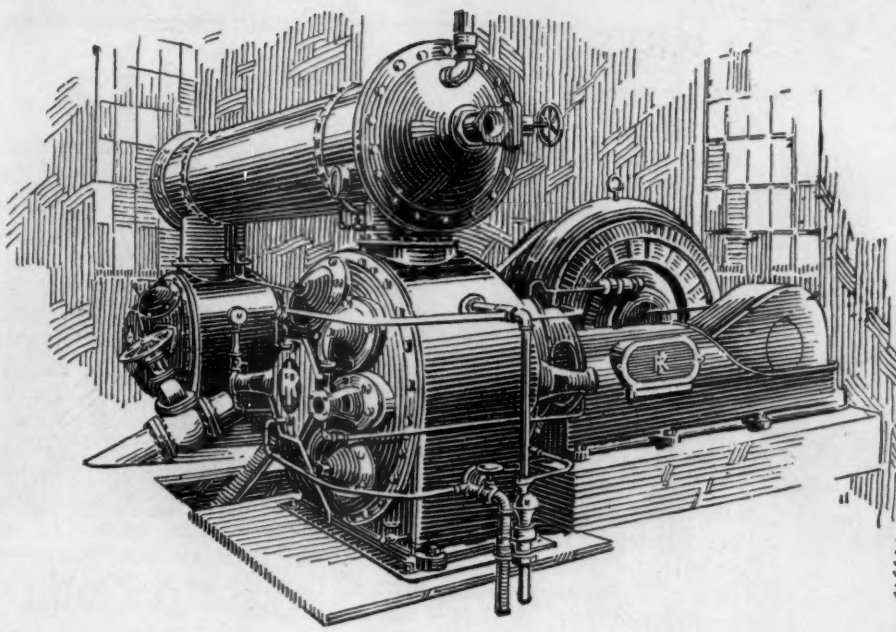
The Coast and Geodetic Survey is one of the great surveying and mapping organizations of the United States. As will be seen from what has been stated above, its particular duty is to make the charts along the coast and to provide the fundamental horizontal and vertical control systems in the interior of the country for the use of others. The topographic branch of the U. S. Geological Survey, another mapping organization, is charged with the duty of extending the topographic surveys and mapping over the interior of this country and of Alaska.

There are other surveying and mapping operations carried on by the Federal Government, but they are mere incidents to the main objects for which the organizations were created. Thus we have the surveying and charting and mapping done by the Mississippi River Commission, and the surveying and mapping by the Bureau of Soils, the U. S. Forestry Service, the Reclamation Service, and the Indian Service.

The Hydrographic Office of the U. S. Navy is charged with the duty of reproducing the sailing charts of other nations and in making charts of those foreign waters which have been surveyed by vessels of the U. S. Navy. Its principal field work is done off the coasts of Cuba and Santo Domingo.

In addition to the work that the Coast and Geodetic Survey is doing for the making of navigational charts to aid the navigator and to establish control stations in the interior of our country, a certain amount of research is undertaken. The principal field work connected with this research are observations made for the determination of the value of gravity and the operation of seismological stations. At present, there are only five seismological stations and these are identical with the magnetic observatories, but undoubtedly there will be more activity during coming years in the seismological fields since Congress has

*(Continued on page 200)*



## *A Willing and Indispensable Servant*

IFTY-FIVE YEARS AGO a young inventor named Simon Ingersoll decided to pit his skill and inventive talents against the crude, laborious methods of hand drilling then in use. The result of his experiments was the original rock drill. Curiosity seekers crowded about at its first demonstration; but only a few saw in the tool the first of those applications which were later to make air-power a sister force to electricity and steam.

Since that time, hundreds of practical appliances have supplanted the original rock drill, and powerful, high-pressure machines have made of compressed air a willing and indispensable servant.

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# Ingersoll-Rand

# X-Rays

*(Continued from page 163)*

almost inconceivably small distance yet it is quite simply measured with a high degree of precision.

Perhaps the most striking and generally known property of X-radiation is its very great generating power in materials which are quite opaque to ordinary light. This property was largely responsible for the discovery of X-rays and opened up a large and important field of usefulness. It made possible the examination, without damage, of the interior of a great variety of opaque objects and the science of radiography, which is a subject in itself, resulted. When a beam of X-rays passes through a material, part of the energy is absorbed and the emergent beam has been decreased in intensity. The amount of the absorption depends upon quality of the X-ray beam, the thickness of the object and the nature of the material through which it is passing. Thus a thick object will absorb more than a thin one and a material of high density such as lead or copper, will absorb more than aluminum or wood. The image obtained, when a beam is passed through an object consisting of different materials or different thicknesses of the same material, is really a shadow picture of the object in which the thick or dense parts are less intense than the light or thin parts. In this way, a very good idea of the interior construction can be obtained. Everyone is familiar with the important application of this process in the medical field but few realize that radiography is now being employed to a considerable extent in industrial problems in cases of structures of metals, wood, insulating materials and particularly in the case of metallic castings. If it is understood that a casting or welded joint or similar article can be examined and its soundness, or lack of it, definitely determined all without injuring or changing the object in any way, the importance of the method will be evident. The subject of radiography will be considered in detail later.

The human eye is not sensitive to X-radiation but fortunately it possesses properties which make its presence detectable in a simple fashion. The first of these properties and the one by means of which the radiation was first discovered is that of producing fluorescence in certain salts. The energy of the radiation is absorbed by the fluorescing material and is converted, by a process which we know very little about, into energy of a much lower frequency and which is visible to the eye. A crystal of one of these fluorescent materials exposed to X-rays in a darkened room will glow in an unmistakable manner and with a color which is characteristic of its composition. This property is put to practical use by making a screen of cardboard covered with a thin layer of a fluorescent substance and this may be used for the visual examination of objects by means of X-rays. The materials which show the most marked fluorescence under the influence of X-radiation are, barium platinocyanide, zinc silicate, and calcium tungstate. They must be very carefully and uniformly prepared so that the screen will glow with a uniform brilliance over its whole surface.

Another property which is used for much the same purposes as the preceding is the fact that a photographic emulsion is sensitive to the radiation in the same way that it is sensitive to ordinary light. This makes it possible to take photographs by means of X-rays and to indicate definitely their presence. Since X-rays are not sensibly refracted by ordinary media, we have no lenses and the photographs are merely shadow pictures of the projection of the objects, but even with this limitation the results are quite remarkable. The ordinary films and plates for photographic work will give good results with X-rays but films designed particularly for X-ray work have a heavy emulsion and are often coated on both sides. These films are quite sensitive and under ordinary conditions a picture of the hand for instance may be taken with an exposure of less than a second.

Another property of X-radiation which is used for detecting its presence is that of rendering a gas conducting. Ordinarily, a gas is a good electrical insulator but when it is exposed to X-radiation, the energy is absorbed by the neutral atoms or molecules and they are broken up into positive and negative ions which will move under an electric field and hence conduct a current. This process is known as ionization. An ionization chamber which makes use of this effect for measuring the intensity of X-rays consists of a vessel containing two carefully insulated electrodes and a gas. The electrodes are connected to a battery and a very sensitive current indicating device and when X-rays are admitted to the space between the electrodes, the gas becomes ionized and conducting, and the reading of the current indicator is a measure of the intensity of the X-ray beam. This method is more nearly quantitative than the other two but is much more complicated and difficult to use.

It was discovered, early in the study of X-ray phenomena, that X-rays traveled in straight lines, were not deflected in electric or magnetic fields, were not reflected by mirrors and could not be changed in direction by prisms or diffraction gratings. With our present knowledge of the nature and very short wavelength of X-rays, these results would be expected. In 1913, it was discovered that if the diffraction grating were made sufficiently fine, so that its dimensions were of the same order as the distances between atoms the X-rays would be diffracted exactly as ordinary light. This discovery, which was the direct result of careful planning and calculation, may be considered as one of the most important of modern times for it opened up the whole field of crystallography from a new point of view and also made possible a very powerful method of studying the details of the X-rays themselves.

This phenomenon of the diffraction of X-rays is so important and far-reading that it merits a little discussion. The atoms of which a material is composed, possess the property of scattering X-ray. That is, each atom, when illuminated by the radiation becomes a secondary source and reradiates the energy in all directions. This scattered radiation from a single atom is extremely faint and could not be detected by ordinary methods but if there are a great number of atoms arranged in a regular fashion, the energy scattered by these atoms will combine in certain directions and in these directions the scattered energy will be sufficiently intense to detect. This may be demonstrated in a very simple manner. A beam of X-rays, defined by small pin holes is allowed to fall upon a photographic film and after a suitable exposure, the film is developed. It will be found that the film has one black spot in the center which is the same shape as the pin hole, indicating that the X-rays travel in straight lines. If this process is repeated with a thin crystal of rock salt between the pin hole and the film, the black spot appears as before, due to the radiation which has passed through the crystal but around it are a number of other much fainter spots

*(Continued on page 192)*

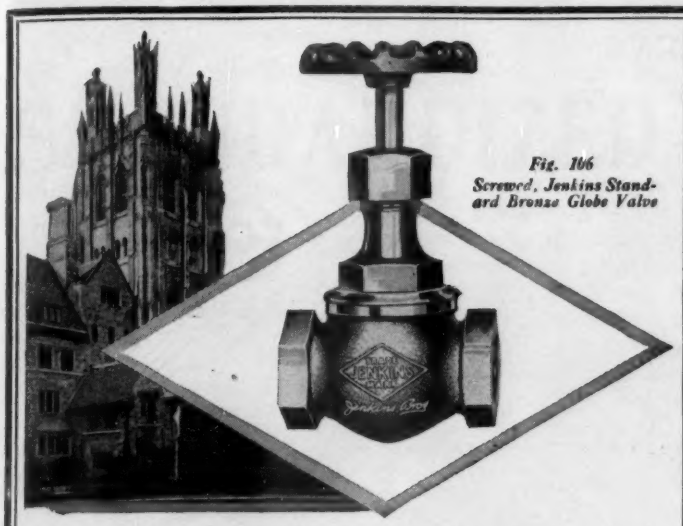

*Fig. 106*
*Screwed, Jenkins Standard Bronze Globe Valve*

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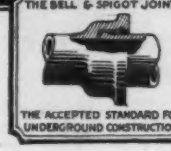


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# X-Rays

*(Continued from page 190)*

arranged in a symmetrical fashion and these are due to the scattered X-rays from the regularly arranged atoms of the crystal. It is found that this pattern of spots depends upon the particular crystal and upon the orientation of the crystal with respect to the X-ray beam as would be expected. An object which is not crystalline will not produce a regular pattern of spots in this fashion but will cause only a slight fogging over the surface of the film in addition to the central spot and this brings up the question of the difference between crystals and non-crystals.

It has long been believed and since the advent of X-ray methods definitely proven, that the characteristic of the crystalline state of solid aggregation is regularity in the arrangement of atoms and groups of atoms. As contrasted with this, the amorphous state is one of a random or chaotic arrangement of atoms and there is no observable regularity. There are many types of patterns upon which the atoms may be arranged, some very simple and others extremely complicated and many materials have their atoms arranged in the same way but on a slightly different scale but up to the present, no two different substances have been found which have exactly the same arrangement as regard both type and size. Aluminum and copper for instance have the same relative atomic arrangement but the atoms of the former are more than ten percent farther apart than in the latter.

By making use of this property which regularly arranged atoms possess of scattering or diffracting X-rays in certain directions, it has been possible to develop methods for studying the arrangement itself. In many cases the arrangement has been completely worked out but in every case, the diffraction effects which the arrangements produce are characteristic of the arrangement and a very excellent and definite method of identification has resulted. This is a very interesting and important subject and will be considered in detail at a later time. This process may also be reversed for the purpose of studying the X-radiation itself. If a crystal of known atomic arrangement is used with radiation of different wavelengths, the diffraction effects will be characteristic of the radiation itself and this process is used for the study of X-ray spectra. It is interesting to observe that X-ray spectra are quite simple as compared with spectra in the visible region. The X-ray spectra of all the elements are of the same type and obey such simple laws that the spectra of the several elements as yet undiscovered have been completely predicted.

Much has been said about X-rays and their properties and perhaps it would be well to indicate how they are produced in practice.

It has been found that when atoms of a solid substance are excited by an intense bombardment of rapidly moving electrons they will emit radiation that we call X-rays, and all X-ray tubes depend upon this phenomenon for their operation. The various types which are to be found differ in the method of producing the fast moving electron. The type in most common use is known as the Coolidge tube and is the invention of Dr. W. D. Coolidge, M.I.T., '96. It consists of a spherical glass bulb with two side arms, evacuated as completely as possible and containing two electrodes. The negative electrode a cathode is composed of a flat spiral of tungsten wire mounted inside of a small metal cup and this filament can be heated from a storage battery or other low voltage source to a high temperature so that it will emit electrons in large quantities. The positive electrode is known as the target and consists of a rather massive metal block with a surface of tungsten or other refractory metal. The hot cathode, when charged to a high negative potential with respect to the target really constitutes an electron gun which shoots electrons at a small spot on the target and this spot becomes the source of X-rays.

The quantity of X-rays produced is dependent on the number of electrons which strike the target and this may be controlled by the temperature of the filament as in any thermionic device. The other important characteristic of the radiation, namely wavelength, is dependent upon the speed of the electrons as they strike the target and this may be controlled by the voltage applied to the tube. In practice, this voltage varies between 30,000 and 250,000 volts. Thus with a tube of this sort, the two important characteristics of the radiation, quantity and quality may be controlled independently and in a quite simple and definite fashion.

For the operation of such a tube it is necessary to have a low voltage source of power for heating the filament and a high voltage source for giving the electrons the necessary speed. The filament supply may be

*(Continued on page 194)*

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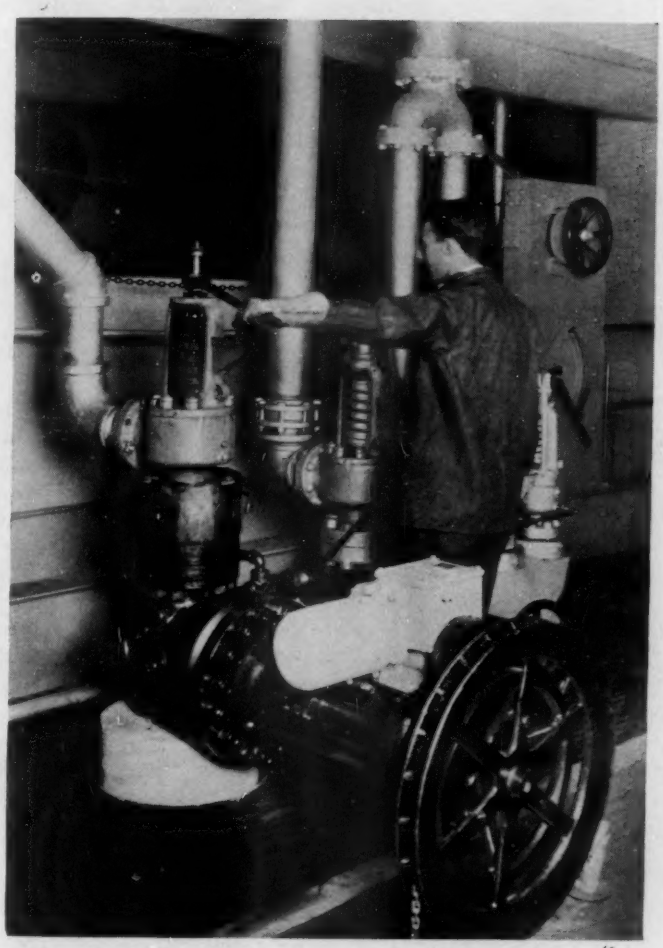

THIS VIEW SHOWS

testing unit of the High Pressure Steam Testing Laboratory of the Consolidated Safety Valve Company, Bridgeport. An actual test is being made of one of the drum valves for the 1200-lb. boiler installed at the Weymouth Station of the Edison Electric Illuminating Co. of Boston.

POWER PLANT engineers are turning to higher steam pressure as a means of economy in producing cheaper power. From 300 lbs., the highest pressure generally used a few years ago, has come the remarkable advance to 400, then to 600, 700, and finally to 1200 lbs. per square inch.

Consolidated Safety Valves tested upon the new 1200-lb. Steam Testing Laboratory of The Consolidated Safety Valve Co. have been installed, or are being furnished, for practically all of the higher pressure stations such as the following:

Form DSA Valves for stations carrying approximately 400-lb. pressure as follows:

**The Trenton Channel Station of The Detroit Edison Co.**

**The Richmond Station of the Philadelphia Electric Co.**

**The Avon Station of the Cleveland Electric Illuminating Co.**

**The 14th Street Station of the New York Edison Co.**

**The Spencer, North Carolina, Station of the Southern Power Co.**

Form DSB Valves for stations carrying approximately 600-lb. pressure as follows:

**The Philo Station of the Ohio Power Co.**

**The Crawford Avenue Station of the Commonwealth Edison Co.**

**The Twin Branch Station of the Michigan & Indiana Electric Co.**

**The Miami Fort Station of the Columbia Power Co.**

Form DSC Valves for the Stanton Power Station of the American Gas & Electric Co., carrying approximately 700 lbs.

Form DSC Valves for the Weymouth Station of the Boston Edison Company, carrying approximately 1200 lbs.

These installations are the best proof that Consolidated Safety Valves for high pressures have passed through the development stage and are being furnished to the trade as a standardized product.

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"Putnam" Machine Tools
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BRIDGEPORT WORKS—CONSOLIDATED SAFETY VALVE CO.

# X-Rays

*(Continued from page 192)*

a storage battery, or what is perhaps simpler for many purposes, a small A.C. transformer with a voltage regulating device. The high voltage source is usually a step-up A.C. transformer. Many tubes require a unidirectional current for their operation and this is obtained by a rectifying device, usually of a mechanical sort in the transformer output circuit. In the case of tubes whose targets are cooled, either by water or other means, no rectifier is necessary because the tube will rectify its own current acting on the principle of a kenotron.

An important point which should be constantly kept in mind when using X-rays is the physiological effect of the radiation on the body. It has been proven in many unfortunate instances that exposure to X-rays may be extremely harmful and in some cases has been directly responsible for the death of the operator. The exposure not only causes a severe burning of the skin but also has its effect upon the interior of the body and it is particularly dangerous because the effect of an over exposure does not make itself evident for a considerable period. It is also supposed that the X-ray effect is a cumulative one and for this reason a person who is regularly engaged in X-ray work has to be very careful of even small doses which would be entirely harmless to an occasional visitor.

To prevent harmful exposure to X-rays, it is usual to enclose the X-ray tube in a shield of lead or some other material which is opaque to X-rays. The dangers in this connection and the methods of protection are at present quite well understood and there is no excuse for mishaps in this connection. If such mishaps occur they may be usually attributed to carelessness.

The present paper has outlined in a brief way some of the characteristics of X-radiation which make possible its applications in a practical way to scientific and industrial problems. It is hoped that this will, in effect, pave the way for a more detailed discussion of some of these more interesting and important applications which the engineer must consider if he is to keep up with the progress of the modern scientific world.

# Midas

*(Continued from page 174)*

the money at 6%, at graduation you will owe about $4500. If after graduation your living expenses continue at $1000 a year and the interest of your debt is $270 a year, then your liabilities, at any time, are,

$$L = 4500 + 1270\,T$$

and the solution of the equation,

$$S\,E_{o}^{T} dT = 4500 + 1270\,T$$

will tell you when your debts will be entirely liquidated. From Fernald's data the root of this equation is just a little beyond T = 5 years. Hence on the average your entire salary, less living expenses, has been mortgaged for five years after graduation for your college education.

We will consider one other interesting calculation. Suppose that a classmate of yours at the end of his high

*(Continued on page 198)*


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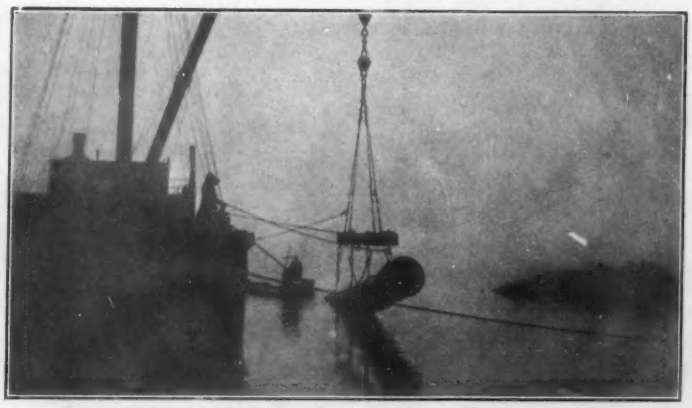

View showing the laying of 48 feet of 30" pipe, made up as one section, for Outfall Sewer at South Boston, Mass. View shows pipe just entering the water and slung so as to take the slope going inshore.

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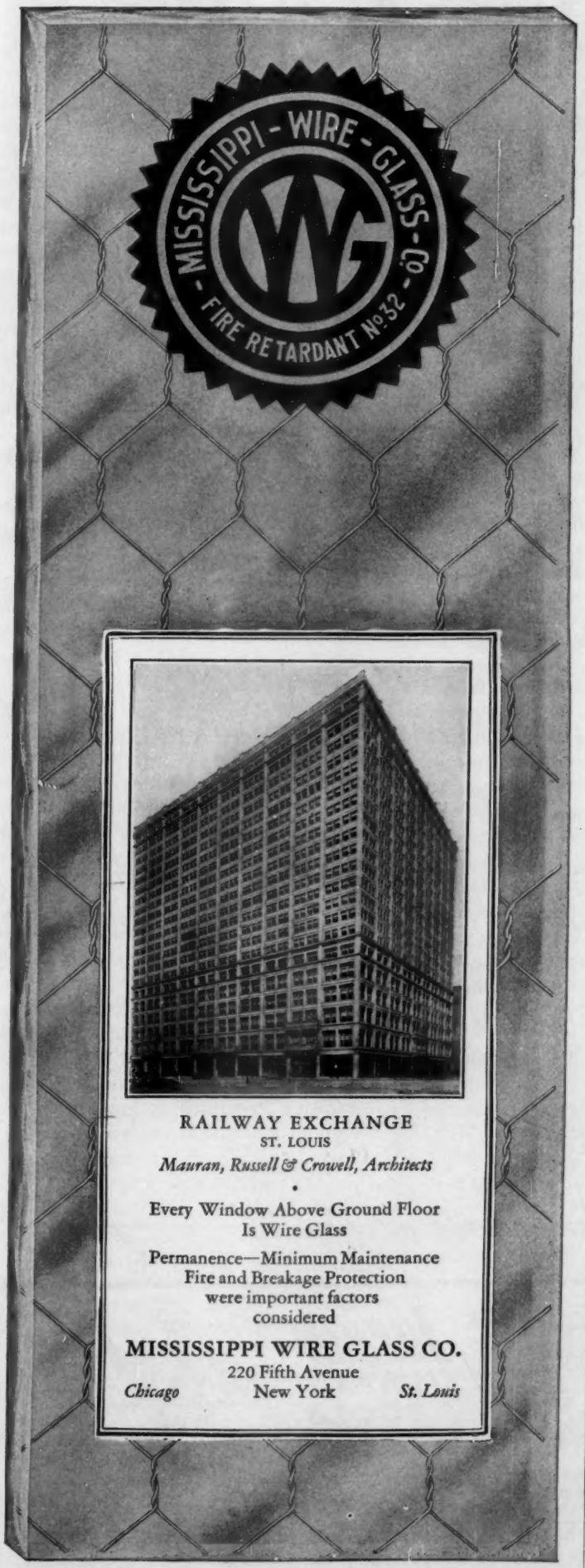


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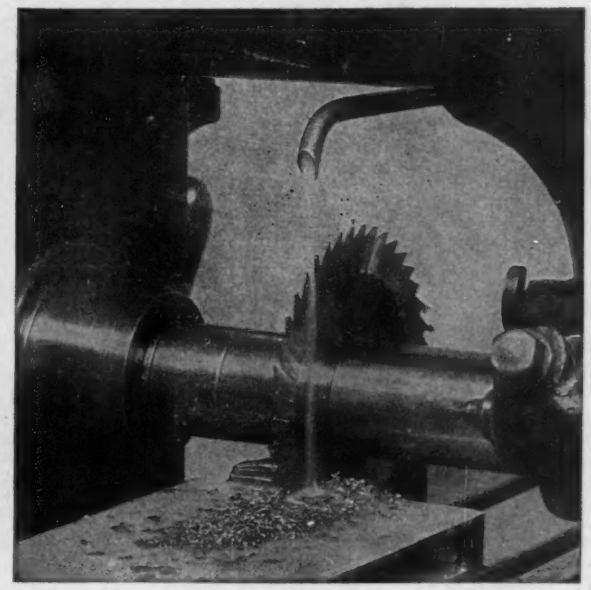

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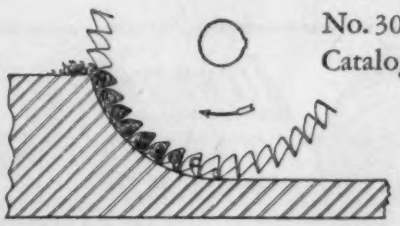
*Note shape of the Teeth giving plenty of side Chip Clearance.*

The clearance on the sides of the teeth behind their cutting edge increases the chip capacity of the saw and makes possible coarser feeds at increased speeds without dragging or clogging. The figure below shows this operation.

There is considerable information about Cutters in the New No. 30 Small Tool Catalog. We will gladly send a copy at your request.



**BROWN & SHARPE MFG. CO.**
**PROVIDENCE, R. I., U. S. A.**

# Engineering and Human Progress

*(Continued from page 165)*

will have the largest development and greatest usefulness in the long run, but not necessarily immediately after graduation from college.

The engineering student is being trained for responsible citizenship and to a realization that the stability of society depends upon men who are obedient to law, who are interested in the common good, who are tolerant of the lawful rights of others and who do not allow sentiment and prejudice to color their views. He is also being impressed with the interdependence of human and property rights, the evils of mob control, and the dangers lurking in class consciousness.

Besides training engineers the engineering colleges of this country have been utilizing their staffs and equipment to solve new problems of value to the public. Engineering educators realize that it is impossible to develop the creative talents of their students unless they are placed in contact with teachers and investigators who are constantly in search of new knowledge. About twenty-five of these engineering colleges have research departments or engineering experiment stations. The publications of these experiment stations include over 500 bulletins which contain valuable new engineering knowledge. Research in the engineering colleges of this country should receive greater encouragement and better support. While the U. S. A. has less than six per cent of the world's population our men of genius are credited with more than two-thirds of the epoch making inventions during the past century. Our accomplishments in the future will be even greater than those in the past if we pay attention to research and to the development of engineers who can create new knowledge.

The engineering colleges of the U. S. A. have continuously adapted their curricula to the changing needs of the times and are constantly trying to train engineers who have courage to do right, ability to think straight, willingness to work hard, personality to make them acceptable to their fellowmen, and breadth of vision to utilize the new forces which engineering is constantly creating for the common good.

This age has been called the "Age of the Engineer". His contributions to human welfare have resulted in giving the people of the U. S. A. among many other advantages one newspaper for every 3 1-2 people, one automobile for every six people, electric lights in every other household, and gas in every fourth household. Through the use of mechanical power to the extent of 7 H. P. per capita our people possess far greater strength and enjoy more luxuries than any people in the history of the world.

It may be well, however, to reflect upon the effect of this new strength of ours, this new power upon our philosophy of life. Are we measuring individual accomplishments in terms of his power over his fellowmen? Do we reward mainly aggressiveness, domination and self-assertion and neglect loyalty and modesty?

We are learning by modern production methods to do things in a big way, but we must not substitute quantity for quality. Every auto manufacturer is striving to turn out the greatest number of cars, city and school officials are constantly striving for the largest student enrollment. This philosophy has resulted in a remark by the late President Roosevelt that "We don't know what thoroughness is". Is it well for us to think of everything in terms of size rather than quality?

The engineer should strive to use his knowledge and his talents in order that man may have more and cheaper power, better systems of transportation and of communication, better cities, more practical methods for heating and cooling buildings, and stronger structures at low cost. The wisdom must be his to utilize the new forces which he is constantly creating for the insurance of true human happiness and the permanency of our civilization.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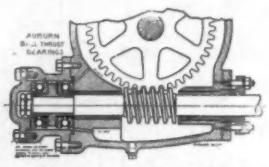

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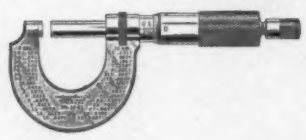

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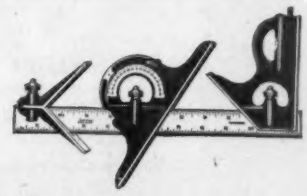

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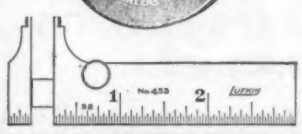

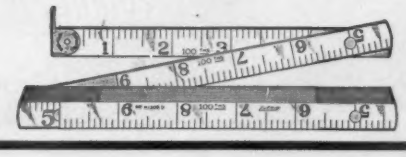

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# Engineering—Legendary Kingdom of Midas

*(Continued from page 194)*

school career could earn $1200 a year, which would in the normal course of promotion have increased to $1800 in four years. Suppose in the next five years his salary increased to $2400 and then due to his limited education it required ten years more to reach the $3000 mark. Assuming the same living expenses, by the time you had paid your college debts he would have about $5,400 saved, if he carefully invested his savings at 6%, but in four years more your total savings will have become just about equal to his. In other words, given two boys of equal average ability, one starting work after graduating from high school, and one borrowing money for a college education, thirteen years later the boy who went to college will have paid his debts with interest, created an estate of approximately $13,000 equal to that of the boy who went immediately to work, and in addition be earning a salary almost double.

To return to Prof. Fernald's study, he found the following distribution of graduates in regard to their salaries for the fifth and tenth years after graduation.

| | *Distribution of Graduates* | |
|---|---|---|
| *Salary Range* | *5th year* | *10th year* |
| $1000-$2000 | 16% | — |
| 2000- 3000 | 44% | 18% |
| 3000- 4000 | 32% | 38% |
| 4000- 5000 | 6% | 11% |
| 5000- 6000 | 2% | 13% |
| 6000- 7000 | — | 2% |
| 7000- 8000 | — | 7% |
| 10000-13000 | — | 11% |

Why is there a marked increase of those earning the very high salaries in the tenth year with comparatively few earning what might be termed the intermediate salary of $6000 to $7000 a year? Well at best the reason is a guess. The author has sought out opinions and there seems to be a variety of explanations. One is that by the tenth year many have married and raised families so that they are not in a position to gamble on what appear to be opportunities. The chances are seized by the unmarried ones or those with few dependents and these attain the highest salaries. Another explanation is that by pure hard work, average individual effort cannot earn more than about $6000 a year, but those who have shown exceptional ability in one form or another are sought out, placed in advisory or executive capacities and highly remunerated. Perhaps both enter into the case and perhaps there is yet another more important influence, but these are at least two plausible explanations.

The old saying that the first million is the hardest to earn, still holds true, for if you are willing to assume the author's equation and have no debts at the end of your college career, it will take you about thirty-five years, at the end of which time you will have to be earning at the tremendous rate of $160,000 a year!

It is safe to say that one's chances of becoming a millionaire rest upon his cleverness and luck. When Bradstreet grants you the A-1 degree, you may be sure that you did not graduate into plutocracy by such wild extrapolations of your salary curve!

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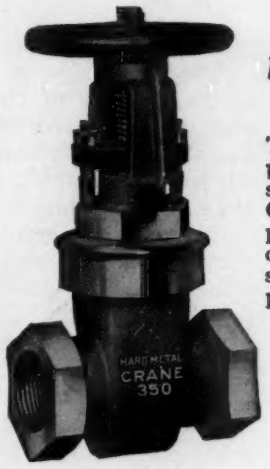


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In the pioneering period of American engineering, Crane Co. is proud to have borne a share. From 1855, when the original Crane brass and bell foundry was launched, until the present, Crane has led in the development of valves. The work of Crane engineers has opened the way to hundreds of engineering feats which the past could not have dreamed. As Crane has served thousands of engineers before you, it seeks to serve you.

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# The Coast and Geodetic Survey

*(Continued from page 188)*

directed the Coast and Geodetic Survey to take up this work.

Recently, we have reproduced the triangulation in California and rerun lines of levels there in order to detect the movements of the earth. The results give promise that this line of activity may have great scientific as well as practical value.

The Coast and Geodetic Survey is now operating a latitude variation station at Ukiah, California. This is one of three latitude variation stations in different parts of the world on approximately the same parallel of latitude. We find from the observations made at these stations that the poles of the earth wander around with a maximum of approximately 30 feet from the mean position. Much has been written on the variation of latitude and the results of this work are of value to those astronomers who must keep accurate account of the positions and movements of the stars. From the variation of latitude observations, we are also able to derive some of the physical properties of the interior of the earth.

One of the projects of the Washington office has been the determination of the figure of the earth. The data used were geographic positions determined by triangulation and latitudes and longitudes determined by observations on the stars. The dimensions of the earth derived from the investigations of the Coast and Geodetic Survey were adopted at the meeting of the International Geodetic and Geophysical Union at Madrid, Spain, in 1924, as the international spheroid. It is believed to be the most reliable one now in existence.

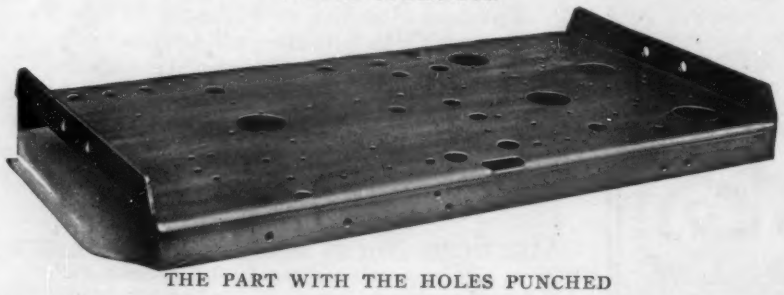
The officials of the U. S. Coast and Geodetic Survey have during a century of existence kept in close touch with the methods and instruments employed by other countries. At times we have benefited by what they have produced and at other times they have adopted our methods and instruments as the best available.

In the instrument line the Coast and Geodetic Survey has done some notable work. We have the tide predicting machine made in that office. It is supposed to be the best one in existence today. We have the precise level designed and made in the office of the Coast and Geodetic Survey which is now the standard instrument for this organization, the U. S. Geological Survey, and for surveying organizations of a number of other countries. Other instruments have been made or have been adapted from foreign designs to meet our special needs in particular lines. It may be said that the instrumental equipment of the Coast and Geodetic Survey is up to date and of high grade, but we are never satisfied with what we have; we are always striving to increase the efficiency of our instruments in order that we may be able to get the requisite degree of accuracy with the smallest number of observations and in the shortest time. There is always a struggle to make increased efficiency offset the higher cost of all the elements that enter into the operations of our organization.

The life of an engineer in the Coast and Geodetic Survey is practically that of the explorer, and no one who does not have at least in part the spirit of the explorer is happy in the out of door and rugged life that our engineers have to live. It is no place for the man who cannot enjoy himself without the attractions of the city or the town.

**Sheet Metal Stampings**

THE DIE THAT PUNCHES ONE HUNDRED AND TWENTY-FIVE HOLES IN ONE OPERATION



THE PART WITH THE HOLES PUNCHED

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"My visit in Pittsburgh was wonderful. Talking to men in plants that have been using I-T-E Circuit Breakers for 20 and 25 years brought to mind the thought of preparing a full page ad for I-T-E telling of the joys, satisfaction, and pride in being heartily welcomed and able to resell concerns for such a long time."

Asst. Sales Mgr.
The Cutter Elec. & Mfg. Co.

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For thirty-six years The Cutter Company has devoted itself entirely to the manufacture of I-T-E Circuit Breakers—the world's standard of excellence in electrical protective appliances. These products have never been sold with the thought of benefit to Cutter alone, but with the thought of benefit to the buyer and to the plant using them.

"Joy in the Job" cannot be obtained by just making a sale—it must include making a friend as well.

The policy of the Cutter Company ever since its establishment in 1888, and of every Cutter representative, is to sell only such products as will insure the making of a friend as well as a re-sale.

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# CUTTER

U-RE-LITE I-T-E CIRCUIT BREAKERS

# Ore Concentration by Flotation

*(Continued from page 173)*

Two of the most noteworthy developments in flotation practice in recent years are: (1) the Sheridan-Grizwold Galena-Sphalerite differential flotation process calling for the use of sodium or potassium cyanide in an alkaline circuit, and (2) the use of sodium and potassium xanthates.

The use of a suitable flotation oil and insignificantly small amounts of sodium or potassium cyanide and a few pounds of sodium carbonate per ton of ore treated permits the flotation of galena to proceed while the sphalerite content of the ore almost completely remains in the pulp and is floated in a subsequent flotation treatment by the addition of copper sulphate.

Xanthates, both sodium and potassium, are powerful flotation promoting agents. A fraction of a pound per ton greatly helps the flotation of the sulphide minerals. Xanthates, like the cyanides in the Sheridan-Grizwold process are used in conjunction with oils.

With every advance of the flotation process gravity concentration has suffered. Coarse jigs have been almost completely routed and in many instances table concentration has given way to all flotation methods. Some of the advantages of an all flotation plant are (1) simplicity of construction and operation, (2) low first cost per ton of ore to be treated, (3) large tonnage can be handled on a small floor space, (4) complex ores require a very fine initial crushing, and if part of the mineral must be recovered by flotation why not all of it by the same process—this makes for simplicity, (5) two minerals of the same, or nearly the same, specific gravity cannot be separated by gravity methods, and (6) high recoveries and good grade products are attainable by the all flotation method. There is, however, still wide use for gravity concentrators, particularly of the reciprocating table type and rather than discourage their use completely, a more careful study of the principles involved and of their operation should be made. The writer believes that the fundamentals of gravity concentration are still not fully understood. If this is correct, there is room for improvements.

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**Colloid Chemistry: Theoretical and Applied. By selected international contributors. Collected and edited by Jerome Alexander. Vol. 1: Theory and Methods. 974 pp. Illustrated. New York: The Chemical Catalogue Company, 1926.**

This is the latest word on colloid chemistry. This first volume is made up of articles by some sixty contributors, drawn from many countries. Two more volumes are to follow, concerning "Biology and Medicine" and "Technology." The first article in this first volume is by the editor on "The Submicroscopic Structure of Matter." A notable article by Friedel, of Strasbourg on "The Mesomorphic States of Matter" deals with the phenomena described by Lehmann in 1889 as "Liquid Crystals." "Colloid Meteorology" by Humphreys deals with atmospheric phenomena and studies of frost and ice masses. The many other articles in the book make it complete as a full report on the present state of this branch of physical chemistry.

---

**Welded Steel Members** and joints were recently tested at the Carnegie Institute of Technology. This was one of the most extensive tests ever made to determine whether the various types of connections required in the frames of buildings can be made satisfactorily by arc welding. The results were excellent and in every case the welds were able to develop the full strength of the steel. In three out of twenty cases the failure occurred at the weld, but even here the ultimate load corresponded closely with the full strength of the connected parts. The elastic behavior was satisfactory in all cases.

Corresponding riveted members and connections were tested in order to establish a basis of comparison. The riveted members gave very satisfactory test of strength and elasticity, but they were surpassed in strength by the competitive welded connections.

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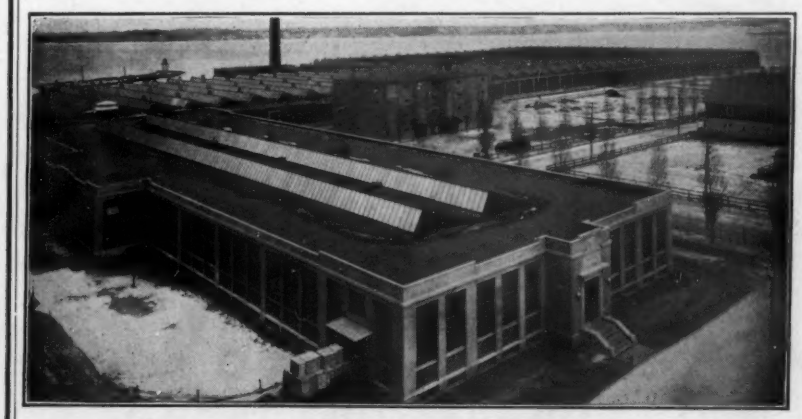

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General Electric Co., Pittsfield, Mass., West Lynn, Mass., Fort Wayne, Ind., Schenectady, N. Y.
Armour & Company, Chicago, Ill.
New York Times, New York, N. Y.
Western Pacific R. R., Sacramento, Cal.
Reo Motor Car Co., Flint, Mich.
Textile Chemical Co., Providence, R. I.
Ward Baking Co., Brooklyn, N. Y.
Continental Motor Corp., Detroit, Mich.
Crane Company, Chicago, Ill.
The Great Atlantic & Pacific Tea Co., Belleville, N. J.
Allis Chalmers Co., Milwaukee, Wis.
Cheek-Neal Coffee Co., Brooklyn, N.Y.
Baltimore Sun, Baltimore, Md.
Edison Lamp Works, Little Ferry, N. J.
Sprague-Warner & Co., Chicago, Ill.
Bausch & Lomb Optical Co., Rochester, N. Y.
Sunbeam Chemical Co., Evansville, Ind.
Kitty Kake Kone, Atlanta, Ga.
Yellow Cab Manufacturing Co., Chicago, Ill.
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Public Ledger, Philadelphia, Pa.
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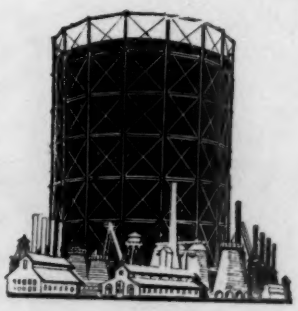

YOU CAN DO IT BETTER WITH GAS

# The National Air Races

*(Continued from page 167)*

an inverted air cooled Liberty engine.

In the light commercial airplane class such names as Buhl-Verville Airster, Pitcairn, Alexander Eaglerock and the Ryan and Fairchild monoplanes have appeared since last year's race. The trend in this class is toward more power; a number of manufacturers have more than doubled their former value. Within the big airplane class the outstanding newcomer is the Ford TriMotor machine. It has been an outgrowth of the single Liberty engined Stout, with the customary changes that are made for the three engine installation. Excellent vision for the pilot, convenient control installation and a roomy cabin are readily noticeable in this machine.

When flying the English Channel in 1909 was as much of an acccomplishment as swimming it is today, such airplanes as the Bleriot monoplane used a wheel at the tail of the machine to hold it off the ground. Later the style changed to a skid which has been adhered to ever since. The early Curtiss pusher type airplanes, famous for their exhibition flying, used a brake to stop the roll upon landing. It consisted of a shoe made of wood which could be pressed against the tire; a rather severe duty for the tire but a light means of brakeing. The return of these devices to airplane construction is noticeable. Although there was no machine at the races which carried a wheel instead of a tail skid it is reported that the three engined Ford has been successfully tested with a wheel at the tail and that the Ford light-plane has a wheel built into the rudder. A discussion among a group of designers at the races indicated further development would be made on this project.

The reason that the wheel might replace the skid is in the rapid application of brakes to the main landing gear wheels. The Ford machine was equipped with a very elaborate hydraulic brakeing mechanism operated from the cockpit by means of a long lever similar to a gear shift lever in an automobile. Major Schroeder, pilot of the craft, gave an excellent demonstration of taxiing by locking either wheel and placing the huge monoplane where he desired, then setting both wheel brakes he opened up the engines and held the machine stationary on the ground. Modified types of the more common automobile brakes were installed on two of the smaller commercial airplanes. A very compact arrangement of brakes and hydraulic shock absorbing landing gear built into a dural disc wheel was observed on the inverted air cooled Liberty pursuit machine.

A flap gear coupled with the ailerons on the Fairchild monoplane was a low speed landing device new to the commercial field this year. The manufacturer of this machine states that the landing speed can be reduced about three miles per hour by the use of the flaps. Flap gears and slots have received considerable attention in England but at present only a few attempts have been made, in the United States, along this line.

Wooden fuselage airplanes are fast becoming obsolete; metal construction taking the place of wood and plywood. The winner of the second speed and efficiency race has been rebuilt this year into a steel tube fuselage machine. One lone "Jenny" of the wartime vintage made its appearance but remained only a day.


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# Abrasives

*(Continued from page 177)*

to consumers for polishing purposes, for manufacture of abrasive papers, or for refractory articles. The greater portion of silicon carbide abrasive is converted into grinding wheels. In this form it enters into the grinding industry, principally shaping and finishing softer metals and materials of low tensile strength.

Close on the heels of the silicon carbide production came the artificial aluminous abrasive of the Norton Company to replace emery and corundum which this company had been using since 1885.

Bauxite ore for this abrasive is found principally in the state of Arkansas. The ore is mined mostly from open pits with steam shovels and tram cars doing the heavy duty. The ore is calcined to free it of the chemically combined water. In this condition it is crushed, carefully sampled and analyzed for the impurities which are reduced to metals in the furnace. The uniform abrasive averaging 95.00% $Al_2O_3$ is made possible by the accurate control of the mixtures through chemical analyses. The amount of coke to add to reduce the $SiO_2$, $Fe_2O_3$, $TiO_2$ and $H_2O$ of the bauxite is based on the reaction at high temperatures where carbon reduces oxides to the respective metals and CO gas.

The mixture is fused in an arc furnace which has movable heads, carbon lined bottom, and a water cooled shell for holding the molten bath. The molten bath is highly conductive. It receives sufficient heat at a given voltage and power input to fuse more mixture, to keep the bath molten as far out as the water-cooled shell and to bring about the necessary chemical reactions. The greater part of the given voltage drop is taken up at the two arcs between the electrodes and the bath. It is at the electrodes where the highest temperatures are reached and therefore the greatest chemical reactions. The reduced metals form an alloy and settle to the bottom in the form of a large button. As more mixture is fed into the furnace, the electrodes come up with the rising molten bath. Finally the furnace shell is filled with molten material which is allowed to cool, first in the water-cooled shell until the chilled crust is strong enough to retain the molten center without breaking, then the whole ingot is removed by crane to a cooling floor where it remains until it is completely chilled.

The cooled ingots or pigs are then cracked open, broken into small lumps, first with hammer and bar and then by crushers. The small lumps from the crushers are passed on to the grain department for final preparation into grains for refractories and abrasive wheels.

It is well to point out that the aluminous abrasives, as they are now produced, are varied in toughness, crystalline structure and chemical purity to give desired qualities for the abrasive industry. This is not true of the silicon carbide abrasive, which is quite uniform in size of crystals and structure. No method yet devised can change the friable crystals of Sic into a tough material. The hardness of either aluminous or silicon carbide abrasives has not been changed.

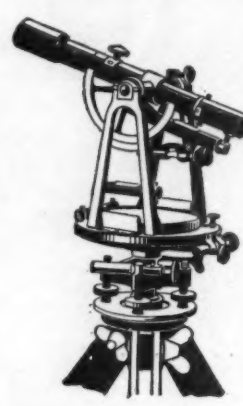
The manufacture of wheels from these artificial abrasive grains is an interesting story in itself but too long to be included in this history and development of artificial abrasives.

The present development of the industry has to offer complete grades and complete combination of grains with the following bonds:

Vitreous or porcelain bond
Silicate bond Shellac bond and
Rubber bond Bakelite bond.

Each of these bonds requires special treatment. Constant study and research work are required to produce uniform product and to improve on the present standards. There is a particular field for each grain, grade and bond for both the artificial silicon carbide and aluminous abrasive wheels. The grinding industry is still young in development and it is reasonable to state that still greater things are to be expected in the way of new bonds and better artificial abrasives.

The development of the grinding machines is another story of constant and rapid advance. From the early types of floor stands, used principally for sharpening tools, to the present 1926 models of precision grinding machines which can finish small metal parts or large rolls weighing tons is a big step taken in a short time. In fact, the advance of the abrasive wheels and grinding machines has kept abreast of the industrial demands. We cannot pay a young but increasingly important industry a better compliment. The end is not yet in sight for the present wonders that are being accomplished daily are merely the beginning of greater things to come.

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*J. W. Legg*

—so studious, inquisitive Joe Legg was told, when he displayed a strange zigzag image covering nearly the whole of an oscillograph film to instructors and fellow students at Worcester Polytechnic Institute back in 1915.

For Legg had done something that had never been done before at Tech. He had corralled the picture of a transient phenomenon. Translated, that means he had been able to photograph the electrical disturbance resulting from the closing and opening of a circuit breaker. From that moment the story of the modern oscillograph is synonymous with the story of Joseph Willard Legg, E. E. '16.

Legg's novel experiment was accomplished by a form of remote control rigged up for the college laboratory's oscillograph. Soon the Westinghouse Company ordered one of his controls. And it was natural that Legg should follow his device to East Pittsburgh the next autumn, after he graduated. First in the Research Department, then in the Material and Process Department, he continued to solve oscillograph problems.

The oscillograph films the records of electric current by means of an apparatus of surpassing delicacy. The most modern type, for instance, has a vibrator strip that is 55/100,000 of an inch thick—⅛ the diameter of a human hair. It contains a mirror 17/1000 of an inch wide.

But before Legg began his study, the oscillograph, itself, was a clumsy contrivance weighing almost half a ton. He proved that a compact oscillograph, operated with an incandescent lamp, was practicable; first, with a three-element model (one that will record the action of three phenomena at the same time) weighing about 135 pounds. This was in 1917. More recently a nine-element oscillograph weighing only 100 pounds has been developed. And, acme of creative genius, Legg has just produced a baby one-element oscillograph, called the OSISO—which weighs but 7½ pounds! For good measure, Legg designed a holder for loading the oscillograph film in daylight, something that had been fruitlessly tried for years.

As a result of these advances, power companies are saved enormous expense in learning vital characteristics of their circuits—and in solving problems faced by their plants. For instance, by devising a way to automatically record chance disturbances on power lines, Legg has made it possible with the OSISO to start recording a picture 1/1000 of a second after lightning causes a flash.

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BOSTON STORE, CHICAGO—*7 in 1905; 2 in 1912; 10 in 1913; 4 in 1926.*
A. HAMBURGER & SONS, LOS ANGELES—*1 in 1908; 7 in 1923.*
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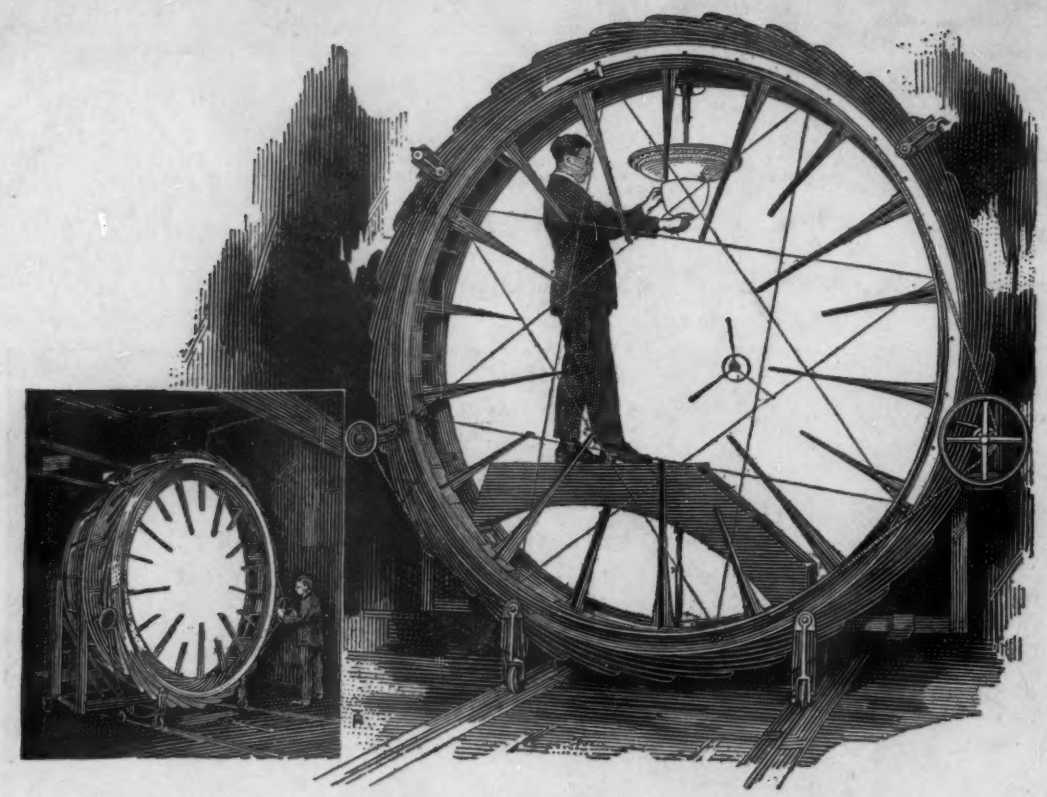

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